PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
PCT 0413		
International application No.	International filing date (day/month/year)	(Earliest) Priority Date (day/month/year)
PCT/NL95/00335	03/10/95	04/10/94
Applicant		
FANCOM B.V. et al.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (see Box I).

2. [ ] **Unity of invention is lacking** (see Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] Transcribed by this Authority

4. With regard to the **title,**
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:
   Figure No. 1
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 95/00335

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01F1/10 G01F25/00 F24F11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01F F24F A01K G01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 545 499 (INDOLEC B V) 9 June 1993 see column 12, line 32 - column 13, line 1; figure 4	1,9,14
A	EP,A,0 589 532 (KEMPENSERVICE ELEKTROTECHNIEK) 30 March 1994 see column 5, line 17 - line 53; figure 2	1,14
A	EP,A,0 100 214 (NAT RES DEV) 8 February 1984 see page 4, line 24 - page 5, line 10; figure 1	14
A	EP,A,0 016 321 (VDO SCHINDLING) 1 October 1980 see page 7, line 22 - line 30; figure 3	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
4 January 1996	- 5. 02. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Heinsius, R

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 95/00335

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0545499	09-06-93	NL-A-	9102016	01-07-93
EP-A-0589532	30-03-94	NL-A-	9201645	18-04-94
EP-A-0100214	08-02-84	DE-A-	3377008	14-07-88
		GB-A,B	2125191	29-02-84
EP-A-0016321	01-10-80	DE-A-	2911827	09-10-80
		AU-B-	528022	31-03-83
		AU-B-	5568380	02-10-80
		JP-C-	1286673	31-10-85
		JP-A-	56058612	21-05-81
		JP-B-	60008446	02-03-85
		US-A-	4316392	23-02-82

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

RECORD COPY

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International Application No. PCT/NL 95 / 00335

International Filing Date 03 OKT. 1995 (03. 10. 95)

BUREAU VOOR DE INDUSTRIËLE EIGENDOM
P.C.T. INTERNATIONAL APPLICATION
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* PCT 0413

Box No. I TITLE OF INVENTION

Flow sensor

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Fancom B.V.
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the Netherlands

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(i.e. country)* of nationality: Netherlands (NL)

State *(i.e. country)* of residence: Netherlands (NL)

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

RO

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

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☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

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State *(i.e. country)* of residence: Belgium (BE)

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Ir. Th.A.H.J. Smulders, c/s.

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Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

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This person is:
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- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: Belgium (BE)

State *(i.e. country)* of residence: Belgium (BE)

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

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This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: Belgium (BE)

State *(i.e. country)* of residence: Belgium (BE)

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Jansen, Gijs
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the Netherlands

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: (NL)

State *(i.e. country)* of residence: (NL)

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

[ ] Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

[X] AP **ARIPO Patent:** KE Kenya, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda and any other State which is a Contracting State of the Harare Protocol and of the PCT

[X] EP **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, DE Germany, DK Denmark, ES Spain, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

[X] OA **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

[X] AM Armenia .....
[X] AT Austria .....
[X] AU Australia .....
[X] BB Barbados
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[X] BR Brazil .....
[X] BY Belarus
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[X] CH and LI Switzerland and Liechtenstein
[X] CN China .....
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[X] KP Democratic People's Republic of Korea .....
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[X] KR Republic of Korea .....
[X] KZ Kazakhstan .....
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[X] MD Republic of Moldova .....
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[X] SK Slovakia .....
[X] TJ Tajikistan .....
[X] TM Turkmenistan .....
[X] TT Trinidad and Tobago .....
[X] UA Ukraine .....
[X] UG Uganda .....
[X] US United States of America .....
.....
[X] UZ Uzbekistan .....
[X] VN Viet Nam .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

[X] MK ..Macedonië.....
[ ] .....
[ ] .....
[ ] .....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of _____.

The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country *(in which, or for which, the application was filed)*	Filing Date *(day/month/year)*	Application No.	Office of filing *(only for regional or international application)*
item (1) NL	(04. 10. 1994) 04 October 1994	9401632	
item (2)			
item (3)			

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☐ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s) : _____

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA / EP

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been carried out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. Identify such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request:*

Country (or regional Office):	Date *(day/month/year)*:	Number:
NL	28 June 1994	SN 24966 NL

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	4	sheets
2. description	14	sheets
3. claims	6	sheets
4. abstract	1	sheets
5. drawings	3	sheets
Total	28	sheets

This international application is accompanied by the item(s) marked below:

1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing (diskette)
8. ☐ other *(specify)*:

Figure No. 1 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

J. A. M. J. H. Vossen

For receiving Office use only

1. Date of actual receipt of the purported international application:	03 OKT. 1995 (03. 10. 95)	2. Drawings: ☒ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required corrections under PCT Article 11(2):		
5. International Searching Authority specified by the applicant: ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid	

For International Bureau use only

Date of receipt of the record copy by the International Bureau:	03 NOVEMBER 1995 (03. 11. 95)

Titel: Debietsensor.

De uitvinding heeft betrekking op een debietsensor, in het bijzonder geschikt voor gebruik bij luchtdebietmeting, voorzien van een in een buissectie vrijdraaiend opgehangen vleugelrad.

Bij bekende debietsensoren van het bovengenoemde type wordt als vleugelrad bijvoorbeeld een ventilator-vleugelrad toegepast dat in een buissectie is opgesteld, zodanig dat het daarin vrij kan draaien. De rotaties van het vleugelrad worden gemeten, waarna uit de rotatiesnelheid het door de buissectie stromende debiet met enigerlei nauwkeurigheid wordt vastgesteld. Bij de bekende debietsensoren is het verband tussen een gemeten toerental en het door de buissectie stromende debiet niet lineair en bovendien afhankelijk van de drukval over het meetsysteem. Met name bij lage toerentallen en kleine debieten en bij grote drukverschillen over de kokersectie kan een sterk afwijkend gedrag ontstaan.

Een ventilator-vleugelrad is zodanig ontworpen dat daardoor een rotatie-energie kan worden omgezet in een luchtbeweging. Daarop is het aantal bladen en de blad-configuratie van het ventilator-vleugelrad gekozen. Bij gebruik van een dergelijk ventilator-vleugelrad als vrij-draaiend, dat wil zeggen niet met behulp van een motor of dergelijk middel aangedreven vleugelrad zal, in het bijzonder bij lage toerentallen en/of grote drukverschillen tussen de beide zijden van het vleugelrad het verband tussen de rotatie-snelheid en de debieten die door het door het vleugelrad bestreken oppervlak worden gevoerd sterk afwijken van een lineair verband, en bovendien direct afhankelijk zijn van het drukverschil over de kokersectie.

Bij lage toerentallen en grote drukverschillen zal lucht door het vleugelrad worden teruggevoerd, de zogenoemde back-flow, waardoor bij een gelijkblijvend debiet de rotatiesnelheid van het vleugelrad wordt veranderd, bijvoorbeeld als gevolg van een nabij opgestelde ventilator. Bovendien heeft een ventilator-vleugelrad veelal sterke luchtturbulenties tot gevolg, met eveneens als gevolg dat de

werking van de debietsensor negatief wordt beïnvloed. Dit betekent dat dergelijke debietsensoren een slechte meetkarakteristiek hebben, met name bij lage debieten en dat deze bekende debietsensoren met name niet drukonafhankelijk zijn.

De uitvinding beoogt een debietsensor van de in de aanhef beschreven soort, waarbij de genoemde nadelen zijn vermeden, met behoud van de voordelen. De debietsensor volgens de uitvinding wordt daartoe gekenmerkt door de maatregelen volgens conclusie 1.

De bladhoeken van de verschillende doorsneden van de bladen van het vleugelrad van de debietsensor volgens de uitvinding leveren een debietsensor met een nagenoeg drukonafhankelijke meetkarakteristiek binnen het meetbereik van de debietsensor. De ontwerpkoppel te noemen calibratie-combinatie, bestaande uit een calibratie-debiet en een calibratie-toerental kan daarbij zodanig worden gekozen dat deze meetkarakteristiek eenvoudig aanpasbaar is aan de meetmiddelen en eventuele verdere middelen voor de verwerking van de geregistreerde toerentallen van het vleugelrad tijdens gebruik. De volgens de uitvinding gegeven karakteristiek van het verloop van de bladhoeken over de bladen van het vleugel-rad biedt het voordeel dat, uitgaande van een voor de gewenste toepassing geschikt ontwerpkoppel en een geschikte buissectie-diameter altijd een in hoofdzaak drukonafhankelijke debietsensor kan worden verkregen. Dat wil zeggen dat voor elke toepassing een debietsensor kan worden ontworpen met een in hoofdzaak lineaire meetkarakteristiek, welke meet-karakteristiek ten minste het gekozen ontwerpkoppel omvat. Door de constructie is, zeker in combinatie met een geschikte materiaalkeuze de debietsensor geschikt voor gebruik in stoffige en corrosieve omgevingen, bij sterk wisselende temperaturen en bij verschillende vochtigheden. De debietsensor kan worden gebruikt voor gasdebietmeting maar is ook geschikt voor gebruik bij vloeistofdebietmeting.

Een debietsensor volgens de uitvinding is in het bijzonder geschikt voor gebruik in industriële, agrarische en civiele toepassingen inzake klimaatsturing, procesbeheersing,

emissiesturing, emissiemeting in praktijkomstandigheden en dergelijke.

Een nadere uitwerking van de debietsensor volgens de uitvinding wordt gekenmerkt door de maatregelen volgens conclusie 2.

Bij gebruik van een debietsensor met een vrijdraaiend vleugelrad is het van belang dat het toerental van het vleugelrad tijdens gebruik binnen gegeven grenzen blijft bij een minimaal en maximaal te meten debiet, ten einde verstoringen van de meetkarakteristiek uit te sluiten. Bij te hoge toerentallen zullen bewegingen van de bladen een onrustig gedrag van het vleugelrad tot gevolg hebben waardoor de meetnauwkeurigheid en de gevoeligheid nadelig wordt beïnvloed. Bovendien treden bij te hoge toerentallen van het vleugelrad onaanvaardbare geluidsproductie en slijtage op. Bij te lage toerentallen wordt de meetnauwkeurigheid van de debietsensor te laag.

Ten einde een beter meetgedrag van de debietsensor te verkrijgen binnen het gewenste meetbereik wordt de debietsensor bij voorkeur gekenmerkt door de maatregelen volgens conclusie 3.

In een bijzonder voordelige uitvoeringsvorm wordt de debietsensor volgens de uitvinding gekenmerkt door de maatregelen volgens conclusies 4 en 5.

Door het vleugelrad te voorzien van twee, bij voorkeur diametraal tegenover elkaar gelegen bladen wordt een stabiel vleugelrad verkregen dat eenvoudig kan worden gelagerd, aangezien slechts minimale krachten op de lagering worden uitgeoefend. Het vleugelrad volgens de uitvinding is immers anders dan het vleugelrad van de bekende debietsensoren, niet ontworpen voor de overdracht van energie. Slechts de wrijving van de lagering behoeft overwonnen te worden. Daarbij wordt bovendien slechts een zeer klein deel van het frontaal oppervlak van de buissectie door een stilstaand vleugelrad bestreken. Als gevolg van deze maatregelen is de stromingsweerstand, en daarmee de invloed van het vleugelrad op het stromingspatroon in de buissectie minimaal. Doordat de bladen zich tot nabij de binnenwand van de buissectie

uitstrekken wordt tijdens één omwenteling van het vleugelrad de gehele buissectie bestreken. Dit heeft bij het vleugelrad volgens de uitvinding het voordeel dat het bewegingspatroon daarvan daardoor onafhankelijk is van het stromingspatroon in de buissectie. De debietsensor volgens de uitvinding kan bij zowel turbulente als bij laminaire stroming in de buissectie worden gebruikt zonder dat de meetkarakteristiek wordt beïnvloed terwijl de debietsensor steeds accuraat blijft functioneren.

In een alternatieve uitvoeringsvorm wordt de debietsensor gekenmerkt door de maatregelen volgens conclusie 9.

Door plaatsing van een ventilator in de buissectie wordt een compacte inrichting verkregen die eenvoudig plaatsbaar is, waarbij het vleugelrad en de ventilator optimaal op elkaar kunnen worden afgestemd. Plaatsing van de ventilator stroomafwaarts van het vleugelrad heeft een hoge nauwkeurigheid van de debietsensor tot gevolg.

Het is daarbij bijzonder voordelig indien de debietsensor tevens wordt gekenmerkt door de maatregelen volgens conclusie 10.

De tegengestelde rotatierichting van de ventilator en het vleugelrad geeft een voordelig stromingspatroon binnen de buissectie, waardoor nadelige verstoringen van de meetkarakteristiek, bijvoorbeeld door ongewenste vibraties, worden verhinderd.

De uitvinding heeft voorts betrekking op een vleugelrad van de in de kop van conclusie 14 beschreven soort, welk vleugelrad volgens de uitvinding wordt gekenmerkt door de maatregelen volgens het kenmerkende deel van conclusie 14.

Een dergelijk vleugelrad is bijzonder voordelig plaatsbaar binnen een buissectie en alsdan geschikt voor gebruik bij een debietsensor, aangezien dit in hoofdzaak een drukonafhankelijke rotatie-karakteristiek heeft. Het vleugelrad kan daarbij eenvoudig op de diameter van een geschikte buissectie worden aangepast, zodanig dat bij één rotatie van het vleugelrad binnen de buissectie in hoofdzaak de gehele doorsnede van die buissectie door de bladen wordt bestreken.

De uitvinding heeft bovendien betrekking op een ventilatieinrichting, in het bijzonder geschikt voor gebruik voor de ventilatie van ruimten, en op een werkwijze voor de vervaardiging van een debietsensor, voorzien van een in een buissectie opgesteld vrijdraaiend vleugelrad.

Ter verduidelijking van de uitvinding zullen uitvoeringsvoorbeelden van een debietsensor en een ventilatie-inrichting, onder verwijzing naar de tekening, worden beschreven. Daarin toont:

Fig. 1 een doorgesneden aanzicht van een stal, voorzien van een ventilatieinrichting;

fig. 2 een gedeeltelijk doorgesneden zij-aanzicht van een debietsensor volgens de uitvinding;

fig. 3 een doorgesneden aanzicht van een vleugelrad volgens de lijn III - III in fig. 2;

fig. 4 schematisch de onderzijde van een bladdoorsnede volgens fig. 3; en

fig. 5 een vooraanzicht van een vleugelrad.

Fig. 1 toont een stal 1 die een door een aantal wanden 2, een dak 3 en een vloer 4 bepaalde binnenruimte 5 omvat. In de binnenruimte 5 zijn verwarmingsmiddelen 6 en meetmiddelen 7 voor de bepaling van de samenstelling van de lucht in de binnenruimte 5 aangebracht. In het dak 3 is een buissectie 8 aangebracht die met een eerste open einde 9 in verbinding staat met de binnenruimte 5, en met het tegenovergelegen tweede open einde 10 aansluit op de buitenruimte 11 van de stal 1. In de buissectie 8, die een cirkelvormige binnendoorsnede heeft, is nabij het naar binnen gekeerde eerste open einde 9 een vleugelrad 12 vrij draaibaar opgehangen, welk vleugelrad 12 nog nader zal worden besproken. Nabij het tweede open einde 10 is een ventilator 13 in de buissectie geplaatst, met behulp waarvan lucht vanuit de binnenruimte 5 via de buissectie 8 naar de buitenruimte 11 kan worden afgevoerd.

De verwarmingsmiddelen 6, de luchtsamenstellings-meetmiddelen 7, het vleugelrad 12 en de ventilator 13 zijn alle verbonden met een controle- en stuureenheid 14, bijvoorbeeld een door een computer gestuurde regeleenheid. Met

de regeleenheid 14 zijn tevens gestuurde ventilatie-regelkleppen 15 in de wanden 2, het dak 3 en/of de vloer 4 verbonden. Op basis van de gemeten luchtsamenstelling worden de ventilatie-regelkleppen 15 open en dicht gestuurd, waarbij de ventilator 13 zodanig wordt aangestuurd dat een gewenst luchtdebiet, noodzakelijk voor de verversing van de lucht in de binnenruimte 5, door de buissectie 8 wordt afgevoerd. Het is daarbij van belang dat het afgevoerde luchtdebiet nauwkeurig wordt bepaald en geregeld, ten einde een optimale ventilatie van de binnenruimte 5 te verkrijgen, zonder dat bijvoorbeeld onnodig veel warmte verloren gaat en zonder dat tocht ontstaat.

Het vleugelrad 12 is voorzien van twee diametraal tegenover elkaar geplaatste bladen 16 die zijn bevestigd aan een kern 30 die licht lopend is gelegerd in een huis 32, welk huis met behulp van een aantal radiale spaken 33 centraal is opgehangen binnen de buissectie. De kern 30 heeft een klein frontaal oppervlak en is aerodynamisch gevormd, waardoor het stromingspatroon van de lucht binnen de buissectie 8 minimaal door de kern 30 wordt beïnvloed. De draaiingsas S van het vleugelrad 12 valt samen met de lengteas van de buissectie 8. De bladen 16 strekken zich tot dicht bij de binnenwand van de buissectie 8 uit. De afstand tussen de binnenwand van de buissectie 8 en het vrije einde van het blad 16 bedraagt minder dan 2% van de doorsnede van de buissectie, en bij voorkeur ongeveer 1%. Daardoor wordt tijdens gebruik nagenoeg de volledige dwarsdoorsnede van de buissectie door de bladen 16 bestreken, waardoor de debietsensor zowel bij turbulente als bij laminaire stroming in de buissectie kan worden gebruikt. De draairichting van het vleugelrad is bij voorkeur tegengesteld aan de draairichting van de ventilator.

De buissectie is aan het eerste open einde 9 in de getoonde uitvoeringsvorm voorzien van een naar buiten gebogen instroomrand 31, waarvan de kromtestraal R groter is dan 10% van de diameter D van de buissectie. Het vleugelrad is daarbij bij voorkeur ofwel geplaatst ter hoogte van de instroomrand 31, ofwel op een afstand van de instroomrand 31 die ten minste de helft bedraagt van de diameter D van de buissectie 8. Door

één van deze configuraties toe te passen wordt invloed van het instroompatroon van de lucht in de buissectie 8 op de meetkarakteristiek van de debietsensor verhinderd. Voorts zijn daartoe het vleugelrad 12 en de ventilator 13 op een onderlinge afstand van elkaar geplaatst, welke afstand ten minste overeenkomt met de diameter D van de buissectie 8.

Voor het meten van het debiet dat door de buissectie 8 wordt gevoerd is het vleugelrad 12 voorzien van meetmiddelen 17 voor het bepalen van het toerental van het vleugelrad 12. Het gemeten toerental is daarbij een indicatie voor het debiet, op basis waarvan met behulp van de regeleenheid 14 bijvoorbeeld de rotatiesnelheid van de ventilator 13 kan worden bijgesteld, de stand van de verschillende regelkleppen 15 kan worden aangepast en de verwarming 6 kan worden bijgeregeld.

Ten einde uit het toerental van het vleugelrad 12 op goedkope en betrouwbare wijze het debiet te kunnen berekenen is het van belang dat er een lineair verband bestaat tussen het debiet en het gemeten toerental, ongeacht drukverschillen tussen de binnenruimte 5 en de buitenruimte 11 en ongeacht het stromingspatroon binnen de buissectie 8. Dit lineaire verband wordt in hoofdzaak bepaald door de configuratie van het vleugelrad 12, en in het bijzonder door de bladconfiguratie.

Voor de bladen 16 van het vleugelrad 12, zoals weergegeven in fig. 2, geldt daartoe dat de bladhoek H van elke doorsnede voldoet aan de vergelijking

$$[tg(H(r)) * Caldeb * C]/[r * D^2] = Calrev \quad [1]$$

waarbij

r = afstand doorsnede ten opzichte van het centrum van de kern (m);
H(r) = bladhoek van doorsnede op afstand r (°);
Caldeb = calibratie-debiet (m^3/h)
Calrev = calibratie-toerental (omw/min)
D = diameter buissectie (m)

waarbij C is gelegen tussen 0,003 en 0,004 bij voorkeur 6,67/1974 is. In de praktijk wijkt de bladhoek bij voorkeur maximaal 3° af van de optimale bladhoek.

De bladhoek H is gedefinieerd als de hoek die het blad 16 insluit met de draaiingsas S van het vleugelrad 12, zoals weergegeven in figuur 3.

Voor het berekenen van de geschikte configuratie voor de bladen 16 is daarbij uitgegaan van een voor de toepassing geschikt ontwerpkoppel te noemen calibratie-combinatie K, die bestaat uit een calibratie-debiet Caldeb en een bijbehorend calibratie-toerental Calrev. Het ontwerpkoppel K wordt daarbij onder andere gekozen op basis van de te gebruiken regeleenheid 14 en toerentalmeetmiddelen 17, en vormt een punt op de meetkarakteristiek van de debietsensor. In tabel 1 zijn als voorbeeld de bladhoeken weergegeven van een vleugelrad 12 dat drukonafhankelijk is, en dat daardoor bijzonder geschikt is voor gebruik in een debietsensor volgens de uitvinding.

Tabel 1

Caldeb	500 m^3/h	Maxdeb	8.000 m^3/h
Calrev	125 omw/min	Maxrev	2.000 omw/min
D	0,45 m	Mindeb	120 m^3/h
C	0,0034	Minrev	30 omw/min

r (m)	H(r) (°)	B (m)
0,05	36,8	0,100
0,06	42,0	
0,07	46,4	
0,08	50,2	
0,09	53,4	
0,10	56,3	0,061
0,11	58,8	
0,12	60,9	
0,13	62,8	
0,14	64,5	
0,15	66,0	0,051
0,16	67,4	
0,17	68,6	
0,18	69,7	
0,19	70,6	
0,20	71,5	0,047
0,21	72,4	

Voor een verdere optimalisering van de debietsensor, en in het bijzonder het vleugelrad 12 wordt vervolgens voor althans het grootste deel van elk blad 16 voor elke doorsnede

een geschikte bladbreedte B bepaald die voldoet aan de vergelijking

$$[r_1*\cos(H_1)*B_1]/[r_2*\cos(H_2)*B_2]>1 \quad [2]$$

waarbij:

r_1 = afstand eerste doorsnede ten opzichte van het centrum van de kern (m);

r_2 = afstand tweede doorsnede ten opzichte van het centrum van de kern (m);

waarbij $r_2 > r_1$;

H_1 = bladhoek eerste doorsnede (°);

H_2 = bladhoek tweede doorsnede (°);

B_1 = Bladbreedte eerste doorsnede (m); en

B_2 = Bladbreedte tweede doorsnede (m),

waarbij voor alle bladhoeken van het vleugelrad geldt dat deze in één kwadrant gelegen zijn en dat de bladhoek H en bladbreedte B over het blad een vloeiend verloop hebben. Voor toepassing van het vleugelrad in een luchtdebietsensor in een situatie zoals gegeven in fig. 1 dient de breedte van het blad daarbij bij voorkeur te liggen tussen de 1 en 15 cm. Voor de in tabel 1 beschreven uitvoeringsvorm is uitgegaan van een bladbreedte B van 10 cm op een afstand van 5 cm. Het verloop van de breedte over het blad is in tabel 1 in de rechter kolom weergegeven. De kern heeft in de getoonde uitvoeringsvorm een doorsnede van ongeveer 10 cm.

Bij luchtdebietmeting met behulp van een vrijdraaiend vleugelrad dient het toerental bij voorkeur binnen een bepaald bereik gehouden te worden. Bij te hoge toerentallen van het vleugelrad 12 bestaat een grote kans op instabiliteit van de bladen 16 van het vleugelrad, waardoor de meetkarakteristiek nadelig wordt beïnvloed. Bovendien treedt daardoor grote slijtage op van de verschillende onderdelen van de inrichting en treedt een onaangenaam geluidsniveau op. Bij te lage toerentallen wordt de meetnauwkeurigheid van de debietsensor te gemakkelijk nadelig beïnvloed.

Voor elk vleugelrad 12 kan, gegeven een maximaal en minimaal toelaatbaar toerental een maximaal en minimaal meetbaar debiet worden bepaald aan de hand van de vergelijkingen

$$[tg(H(r)_{max}) * Maxdeb * C]/[r * D^2] < Maxrev \quad [3]$$

en

$$[tg(H(r)_{min}) * Mindeb * C]/[r * D^2] < Minrev \quad [4]$$

waarbij:

$H(r)_{max}$ = maximale bladhoek doorsnede op afstand r (°);

$H(r)_{min}$ = minimale bladhoek doorsnede op afstand r (°);

Maxdeb = maximaal meetdebiet (m^3/h)

Mindeb = minimaal meetdebiet (m^3/h)

Maxrev = maximaal meettoerental (omw/min)

Minrev = minimaal meettoerental (omw/min)

Door invulling van een bladhoek H en het maximaal toelaatbare toerental in de bovenste vergelijking *[3]* kan op eenvoudige wijze het maximaal meetbare debiet worden bepaald, door invulling van de bladhoek H en het minimaal toelaatbare toerental in de onderste vergelijking *[4]* het minimaal meetbare debiet.

Andersom is het aan de hand van dezelfde vergelijkingen *[3]*, *[4]* eveneens mogelijk aan de hand van het maximaal te meten debiet en het maximaal daarbij toelaatbare toerental een maximaal toelaatbare bladhoek voor elke doorsnede te berekenen, en evenzo een minimale bladhoek voor elke doorsnede door invulling van een minimaal te meten debiet en een minimaal daarbij noodzakelijk toerental. Dit biedt de mogelijkheid voorafgaand aan de bepaling van de bladhoeken voor een vleugelrad 12 de ontwerpgrenzen te bepalen, aan de hand waarvan een gunstige calibratie-combinatie K kan worden gekozen. In tabel 2 is voor een vleugelrad voor de verschillende doorsneden de maximale en minimale bladhoek $H(r)_{max}$, $H(r)_{min}$ weergegeven, uitgaande van de in de kop van tabel 2 gegeven ontwerpcriteria.

Tabel 2

Maxdeb	6.000 m^3/h
Maxrev	2.000 t/min
Mindeb	200 m^3/h
Minrev	30 t/min
D	0,45 m
C	0,0034

straal m	min. hoek (°)	max. hoek (°)
0,05	24.2	45
0,06	28.3	50.2
0,07	32.2	54.4
0,08	35.7	58
0,09	39	60.9
0,10	42	63.4
0,11	44.7	65.5
0,12	47.2	67.4
0,13	49.4	68.9
0,14	51.5	70.3
0,15	53.4	71.5
0,16	55.2	72.6
0,17	56.8	73.6
0,18	58.3	74.5
0,19	59.7	75.2
0,20	60.9	76
0,21	62.1	76.6
0,22	63.2	77.2
0,23	64.2	77.7
0,24	65.1	78.2
0,25	66	78.7
0,26	66.8	79.1
0,27	67.6	79.5
0,28	68.3	79.9

Wanneer een ontwerpkoppel K is gekozen kunnen de optimale bladhoeken H worden bepaald door invulling in de eerste vergelijking *[1]*. Indien blijkt dat de gevonden bladhoeken H te veel buiten de met de derde en vierde vergelijking *[3]*, *[4]* gevonden grenswaarden liggen, kan een aangepaste ontwerpkoppel K worden gekozen. Op deze wijze kan het verloop van de bladhoeken eenvoudig worden geoptimaliseerd. Vervolgens kan voor elke bladdoorsnede de breedte worden bepaald aan de hand van de tweede vergelijking *[2]*, zodanig dat de bladconfiguratie aan de gestelde eisen voldoet en derhalve

drukonafhankelijk is en een gewenste, lineaire meetkarakteristiek levert met een geschikte meetnauwkeurigheid.

Fig. 3 toont een dwarsdoorsnede van een blad 16 van een vleugelrad 12. Het blad 16 heeft een voorzijde 18, een achterzijde 19, een aanstroomzijde 20 en een gebogen bovenzijde 21. De aanstroomzijde 20 is in de weergegeven uitvoeringsvorm nagenoeg vlak, waardoor de drukonafhankelijkheid van het vleugelrad positief wordt beïnvloed. De kromming van het blad, die wordt gegeven door het verschil tussen de instroomhoek $ß_1$ en de uitstroomhoek $ß_2$, zoals weergegeven in fig. 4, is kleiner dan 5°, en bij voorkeur ongeveer 0°. De maximale dikte van het blad bedraagt ongeveer 10% van de bladbreedte, en is gelegen op ongeveer 1/3 van de bladbreedte, gemeten vanaf de voorzijde 18 van het blad 16. De bladhoek H komt overeen met het gemiddelde van de instroomhoek $ß_1$ en de uitstroomhoek $ß_2$.

In fig. 5 is een vleugelrad 40 weergegeven dat geschikt is voor gebruik in een debietsensor die drukonafhankelijk is. De bladhoeken H_1, H_2 van twee doorsneden op verschillende afstanden r_1, r_2 van de kern 30 voldoen daarbij aan de vergelijking

$$(r_2/r_1)*\tan(H_1)=\tan(H_2) \qquad [5]$$

waarbij

r_1 = afstand eerste doorsnede ten opzichte van het centrum van de kern (m);

r_2 = afstand tweede doorsnede ten opzichte van het centrum van de kern (m);

H_1 = bladhoek eerste doorsnede (°);

H_2 = bladhoek tweede doorsnede (°);

Uitgaande van een dergelijk vleugelrad 40 kan op eenvoudige wijze een debietsensor worden samengesteld die nagenoeg drukonafhankelijk is. Daartoe kan bijvoorbeeld, uitgaande van een gekozen bladhoek voor één van de doorsneden van een blad 41, en een geschikt ontwerpkoppel K door invulling van deze waarden in de eerste vergelijking *[1]* een geschikte buissectie-diameter D worden bepaald. Vervolgens kan de lengte L van de bladen 41 op die buissectie worden afgestemd. Invulling van de gevonden waarden en een maximaal

toelaatbaar toerental in de tweede vergelijking *[2]* geeft vervolgens een bovengrens voor het meetbereik van de debietmeter, invulling van de derde vergelijking *[3]* op vergelijkbare wijze een ondergrens. Aangezien de debietsensor een lineaire meetkarakteristiek heeft kan eenvoudig worden bepaald of dit maximale toerental daarbij ook daadwerkelijk zal optreden. Wanneer dit overschreden dreigt te worden zal een andere calibratie-combinatie gekozen moeten worden waarbij derhalve een andere diameter van de buissectie zal horen. Op deze wijze kan steeds de geschikte configuratie voor een drukonafhankelijke debietsensor met het gewenste meetbereik worden verkregen, uitgaande van het vleugelrad 40. Uiteraard kan ook, uitgaande van een ontwerpkoppel, voor iedere buissectiediameter door invulling van de gevonden waarden in vergelijking *[1]* de geschikte bladhoek worden bepaald.

Met een werkwijze volgens de uitvinding kan een debietsensor worden verkregen die kan worden toegepast in bijvoorbeeld agrarische, industriële en civiele toepassingen voor gebruik in klimaatsturing, procesbeheersing, emissiemeting en dergelijke. De debietsensor kan worden gebruikt voor bijvoorbeeld lucht- en vloeistofdebietmeting in corrosieve en stoffige omgevingen, bij verschillende temperaturen en vochtigheidsgraden.

De debietsensor kan worden ingericht voor meting van debieten tussen 200 en 6000 m^3/h, maar ook grotere en kleinere debieten zijn mogelijk. De bladlengte van het vleugelrad kan ten minste variëren tussen 15 en 40 cm, maar ook grotere en kleinere bladlengten zijn mogelijk. De debietsensor volgens de uitvinding is ten minste bruikbaar bij drukverschillen tussen 0 en 120 pascal en kan een meetnauwkeurigheid bereiken van $\pm$ 60 m^3/h of minder over het gekozen meetbereik. De uitvinding is uiteraard niet beperkt tot de uitvoeringsvormen zoals weergegeven bij wijze van voorbeelden. Vele variaties zijn mogelijk binnen het raam van de uitvinding.

Zo kan het vleugelrad zijn voorzien van een ander aantal bladen en kan de debietsensor worden gebruikt zonder ventilator, bijvoorbeeld bij natuurlijke ventilatie. Op de

regeleenheid kunnen andere sensoren worden aangesloten, zoals bijvoorbeeld mechanische schakelaars en tijdschakelaars.

In de regeleenheid kunnen verschillende regelprogramma's zijn opgenomen, ingericht voor het beheersen van een proces waarin de debietsensor is opgenomen.

De debietsensor respectievelijk het vleugelrad volgens de uitvinding kan, uitgaande van één of meer van de gegeven parameters, steeds optimaal op het te beheersen proces worden afgestemd. De keuze van de grootte van de parameters wordt daarbij binnen het bereik van de vakman geacht.

CONCLUSIES

1. Debietsensor, in het bijzonder geschikt voor gebruik bij luchtdebietmeting, voorzien van een in een buissectie vrijdraaiend opgehangen vleugelrad dat is voorzien van een centrale kern en een aantal zich vanaf de kern uitstrekkende bladen, waarbij ten minste één blad zich vanaf de kern uitstrekt tot nabij de binnenwand van de buissectie, waarbij meetmiddelen zijn opgenomen voor het meten van het aantal omwentelingen van het vleugelrad per tijdseenheid, waarbij de debietsensor is ingericht voor het bij een door de buis voeren van een calibratie-debiet met behulp van de meetmiddelen registreren van een bijbehorend calibratie-toerental van het vleugelrad, waarbij voor ten minste een reeks doorsneden van het blad geldt dat de bladhoek in hoofdzaak voldoet aan de formule

$$[tg(H(r)) * Caldeb * C]/[r * D^2] = Calrev$$

waarbij

r = afstand doorsnede ten opzichte van het centrum van de kern (m);
H(r) = bladhoek van doorsnede op afstand r (°);
Caldeb = calibratie-debiet (m^3/h)
Calrev = calibratie-toerental (omw/min)
D = diameter buissectie (m)

waarbij $0,003 < C < 0,004$, en waarbij C bij voorkeur 6,67/1974 is.

2. Debietsensor volgens conclusie 1, met het kenmerk, dat voor elke doorsnede van het blad geldt dat de bladhoek in hoofdzaak voldoet aan de formules

$$[tg(H(r)_{max}) * Maxdeb * C]/[r * D^2] < Maxrev$$

en

$$[tg(H(r)_{min}) * Mindeb * C]/[r * D^2] < Minrev$$

waarbij:

$H(r)_{max}$ = maximale bladhoek doorsnede op afstand r (°);
$H(r)_{min}$ = minimale bladhoek doorsnede op afstand r (°);
Maxdeb = maximaal meetdebiet (m^3/h)

Mindeb = minimaal meetdebiet (m^3/h)

Maxrev = maximaal meettoerental (omw/min)

Minrev = minimaal meettoerental (omw/min)

3. Debietsensor volgens conclusie 1 of 2, met het kenmerk, dat voor in hoofdzaak elke combinatie van twee doorsneden van het blad geldt dat

$$[r_1*\cos(H_1)*B_1]/[r_2*\cos(H_2)*B_2]>1$$

waarbij:

r_1 = afstand eerste doorsnede ten opzichte van het centrum van de kern (m);

r_2 = afstand tweede doorsnede ten opzichte van het centrum van de kern (m);

waarbij $r_2 > r_1$

H_1 = bladhoek eerste doorsnede (°);

H_2 = bladhoek tweede doorsnede (°);

B_1 = Bladbreedte eerste doorsnede (m); en

B_2 = Bladbreedte tweede doorsnede (m),

waarbij voor alle bladhoeken van het vleugelrad geldt dat deze in één kwadrant gelegen zijn en dat de bladhoek (H) en bladbreedte (B) over het blad een vloeiend verloop hebben.

4. Debietsensor volgens één der voorgaande conclusies, met het kenmerk, dat het vleugelrad is voorzien van twee bladen die te zamen met de kern de gehele diameter van de betreffende doorsnede van de buissectie bestrijken, waarbij de bladen bij voorkeur diametraal tegenover elkaar zijn aangebracht.

5. Debietsensor volgens één der voorgaande conclusies, met het kenmerk, dat de afstand tussen het vrije einde van het of elk blad en de binnenwand van de buissectie minder dan 2%, en bij voorkeur ongeveer 1% van de diameter van de buissectie bedraagt.

6. Debietsensor volgens één der voorgaande conclusies, met het kenmerk, dat voor elk blad de bladkromming aan de aanstroomzijde kleiner is dan 5°, en bij voorkeur ongeveer 0°.

7. Debietsensor volgens één der voorgaande conclusies, met het kenmerk, dat voor een doorsnede van elk blad geldt dat de doorsnede de grootste dikte heeft op een afstand van ongeveer 1/3 van de bladbreedte, gemeten vanaf de voorrand van het

blad, waarbij de grootste bladdikte bij voorkeur ongeveer 10% van de betreffende bladbreedte bedraagt.

8. Debietsensor volgens één der voorgaande conclusies, met het kenmerk, dat de kern een frontaal oppervlak heeft dat niet meer bedraagt dan ongeveer 10% van de inwendige doorsnede van de buissectie.

9. Debietsensor volgens één der conclusies 1-8, met het kenmerk, dat in de buissectie, stroomafwaarts van het vleugelrad een ventilator is aangebracht voor het via de buissectie vanaf de van de ventilator afgekeerde zijde van het vleugelrad aanzuigen van lucht door het door het vleugelrad tijdens een omwenteling bestreken vlak en het afgeven van die lucht naar buiten de buissectie.

10. Debietsensor volgens conclusie 9, met het kenmerk, dat tijdens gebruik de ventilator tegengesteld draait aan het vleugelrad.

11. Debietsensor volgens conclusie 9 of 10, met het kenmerk, dat de afstand tussen de bladen van de ventilator en de bladen van het vleugelrad ten minste overeenkomt met de diameter van de buissectie.

12. Debietsensor volgens één der conclusies 9-11, met het kenmerk, dat de buissectie aan de zijde van het vleugelrad is voorzien van een naar buiten gebogen instroomrand die een kromtestraal heeft die groter is dan 10% van de diameter van de buissectie, waarbij het vleugelrad is geplaatst ter hoogte van de instroomrand.

13. Debietsensor volgens één der conclusies 9-11, met het kenmerk, dat de buissectie aan de zijde van het vleugelrad is voorzien van een naar buiten gebogen instroomrand die een kromtestraal heeft die groter is dan 10% van de diameter van de buissectie, waarbij het vleugelrad is geplaatst op een afstand van de instroomrand die ten minste de helft van de diameter van de buissectie bedraagt.

14. Ventilatieinrichting, in het bijzonder geschikt voor gebruik voor de ventilatie van ruimten, waarbij een debietsensor volgens één der voorgaande conclusies is opgenomen in één van de begrenzingen van een te ventileren ruimte, waarbij schakelmiddelen zijn opgenomen voor het op basis van de door

de meetmiddelen geregistreerde toerentallen van het vleugelrad en een binnen de ruimte gemeten luchtsamenstelling regelen van de door de debietsensor vanuit de ruimte af te voeren hoeveelheid lucht.

15. Vleugelrad voor plaatsing in een buissectie, voorzien van een centrale kern en een aantal zich vanaf de kern uitstrekkende bladen, met het kenmerk, dat voor in hoofdzaak elke combinatie van twee doorsneden van het blad geldt dat de bladhoeken voldoen aan de vergelijking

$$(r_2/r_1)*\tan(H_1)=\tan(H_2)$$

waarbij

r_1 = afstand eerste doorsnede ten opzichte van het centrum van de kern (m);

r_2 = afstand tweede doorsnede ten opzichte van het centrum van de kern (m);

H_1 = bladhoek eerste doorsnede (°);

H_2 = bladhoek tweede doorsnede (°);

16. Vleugelrad volgens conclusie 15, met het kenmerk, dat een calibratie-combinatie van een calibratie-debiet en een calibratie-toerental bestaat waarbij voor in hoofdzaak elke doorsnede van het blad geldt dat de bladhoek voldoet aan de formule

$$[\mathrm{tg}(H(r)) * \mathrm{Caldeb} * C]/[r * D^2] = \mathrm{Calrev}$$

waarbij

r = afstand doorsnede ten opzichte van het centrum van de kern (m);

H(r) = bladhoek op afstand r (°);

Caldeb = calibratie-debiet (m^3/h)

Calrev = calibratie-toerental (omw/min)

D = diameter beoogde buissectie (m)

waarbij $0{,}003 < C < 0{,}004$, en waarbij C bij voorkeur 6,67/1974 is.

17. Werkwijze voor de vervaardiging van een debietsensor, voorzien van een in een buissectie opgesteld vleugelrad dat is voorzien van ten minste een kern, een aantal zich vanaf de kern uitstrekkende bladen, kernlagermiddelen, middelen voor de bevestiging van de kernlagermiddelen in een buissectie en vleugelradrotatie-meetmiddelen, waarbij aan de hand van de

toepassing van de debietsensor en het meetbereik van de meetmiddelen een geschikte buissectie-diameter en een geschikte combinatie van een calibratie-debiet en een daarbij behorend calibratie-toerental wordt gekozen, waarna de bladhoek van elke doorsnede van het blad wordt bepaald, welke bladhoek voldoet aan de vergelijking

$$[tg(H(r)) * Caldeb * C]/[r * D^2] = Calrev$$

waarbij

r = afstand doorsnede ten opzichte van het centrum van de kern (m);
H(r) = bladhoek van doorsnede op afstand r (°);
Caldeb = calibratie-debiet (m^3/h)
Calrev = calibratie-toerental (omw/min)
D = diameter buissectie (m)

waarbij $0,003 < C < 0,004$, en waarbij C bij voorkeur 6,67/1974 is.

18. Werkwijze volgens conclusie 17, met het kenmerk, dat een tijdens gebruik maximaal en minimaal te meten debiet en een daarbij gewenst maximaal en minimaal toerental van het vleugelrad worden bepaald, waarbij voor elke doorsnede een bladhoek wordt gekozen waarvoor geldt dat deze is gelegen tussen twee grenswaarden $H(r)_{max}$ en $H(r)_{min}$ die voldoen aan de formules

$$[tg(H(r)_{max}) * Maxdeb * C]/[r * D^2] < Maxrev$$

en

$$[tg(H(r)_{min}) * Mindeb * C]/[r * D^2] < Minrev$$

waarbij:

r = afstand doorsnede ten opzichte van het centrum van de kern (m);
$H(r)_{max}$ = maximale bladhoek doorsnede op afstand r (°);
$H(r)_{min}$ = minimale bladhoek doorsnede op afstand r (°);
Maxdeb = maximaal debiet (m^3/h)
Mindeb = minimaal debiet (m^3/h)
Maxrev = maximaal toerental (omw/min)
Minrev = minimaal toerental (omw/min)

waarbij $0,003 < C < 0,004$, en waarbij C is bij voorkeur 6,67/1974.

19. Werkwijze volgens conclusie 17 of 18, met het kenmerk, dat voor elke doorsnede van elk blad een breedte en bladhoek wordt bepaald zodanig dat voor in hoofdzaak elke combinatie van twee doorsneden van het blad geldt dat

$$[r_1*\cos(H_1)*B_1]/[r_2*\cos(H_2)*B_2]>1$$

waarbij:

r_1 = afstand eerste doorsnede ten opzichte van het centrum van de kern (m);

r_2 = afstand tweede doorsnede ten opzichte van het centrum van de kern (m);

waarbij $r_2 > r_1$

H_1 = bladhoek eerste doorsnede (°);

H_2 = bladhoek tweede doorsnede (°);

B_1 = Bladbreedte eerste doorsnede (m); en

B_2 = Bladbreedte tweede doorsnede (m),

en zodanig dat voor alle bladhoeken van het vleugelrad geldt dat deze in één kwadrant gelegen zijn en dat de bladhoek (H) en bladbreedte (B) over het blad een vloeiend verloop hebben.

U I T T R E K S E L

Debietsensor, in het bijzonder geschikt voor gebruik bij luchtdebietmeting, voorzien van een in een buissectie vrijdraaiend opgehangen vleugelrad dat is voorzien van een centrale kern en een aantal zich vanaf de kern uitstrekkende bladen, waarbij ten minste één blad zich vanaf de kern uitstrekt tot nabij de binnenwand van de buissectie, waarbij meetmiddelen zijn opgenomen voor het meten van het aantal omwentelingen van het vleugelrad per tijdseenheid, waarbij de debietsensor is ingericht voor het bij een door de buis voeren van een calibratie-debiet met behulp van de meetmiddelen registreren van een bijbehorend calibratie-toerental van het vleugelrad.

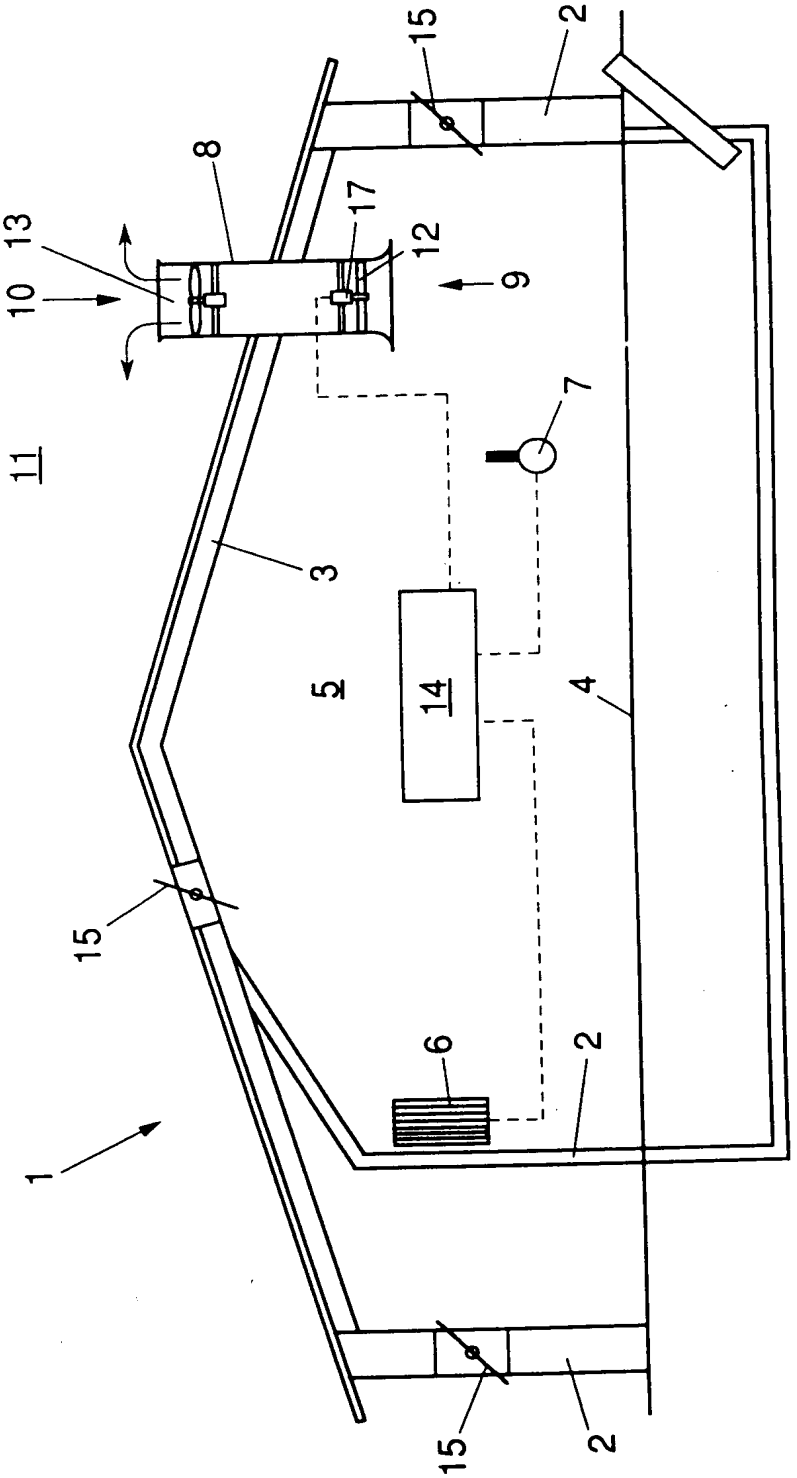

FIG. 1

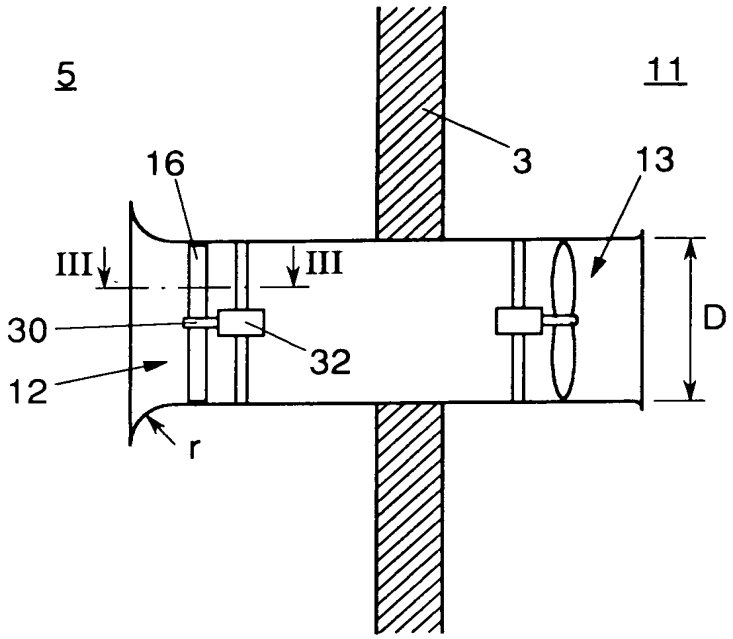

FIG. 2

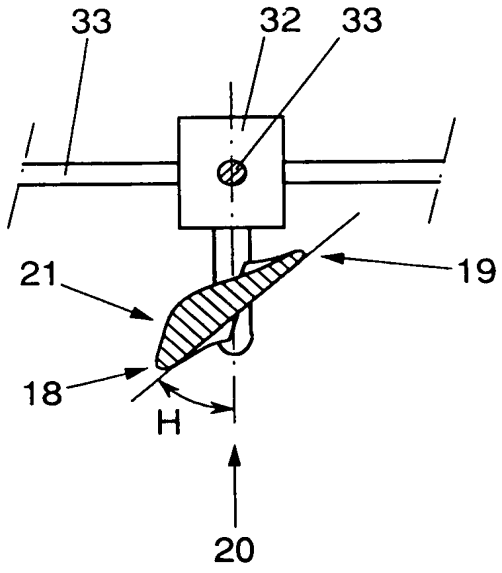

FIG. 3

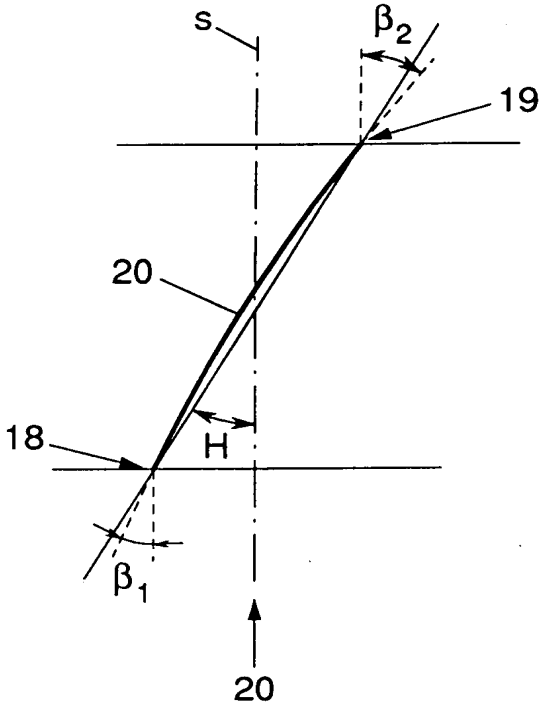

FIG. 4

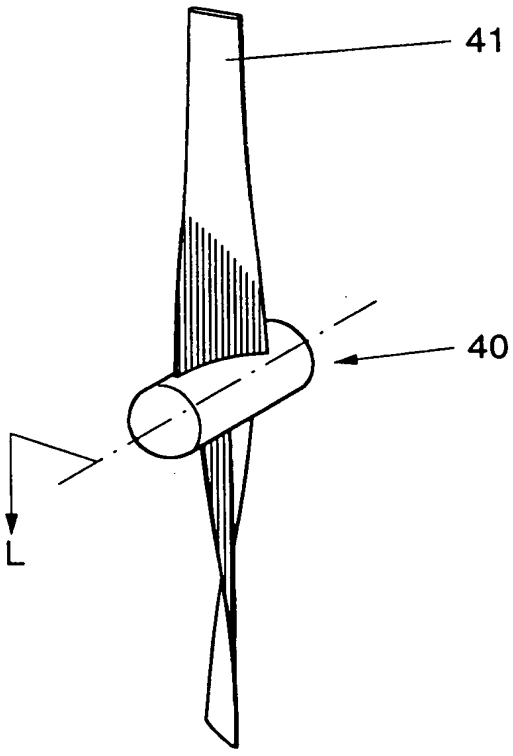

FIG. 5

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* PCT 0413

Box No. I TITLE OF INVENTION

Flow sensor

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Fancom B.V.
Industrieterrein 34
5981 NK Panningen
the Netherlands

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(i.e. country)* of nationality: NL

State *(i.e. country)* of residence: NL

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Berckmans, Daniel

c/o Katholieke Universiteit Leuven
Kardinaal Mercierlaan 92
B-3001 Heverlee
Belgium

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: BE

State *(i.e. country)* of residence: BE

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Ir. Th.A.H.J. Smulders, c.s.

c/o VEREENIGDE OCTROOIBUREAUX
Nieuwe Parklaan 97
2587 BN The Hague
the Netherlands

Telephone No. 070 - 3500464

Facsimile No.

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Vranken, Erik

c/o Katholieke Universiteit Leuven
Kardinaal Mercierlaan 92
B-3001 Heverlee
Belgium

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: BE

State *(i.e. country)* of residence: BE

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Goedseels, Victor

c/o Katholieke Universiteit Leuven
Kardinaal Mercierlaan 92
B-3001 Heverlee
Belgium

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: BE

State *(i.e. country)* of residence: BE

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- [X] **AP** **ARIPO Patent:** KE Kenya, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda and any other State which is a Contracting State of the Harare Protocol and of the PCT
- [X] **EP** **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, DE Germany, DK Denmark, ES Spain, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- [X] **OA** **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- [X] **AM** Armenia .....
- [X] **AT** Austria .....
- [X] **AU** Australia .....
- [X] **BB** Barbados
- [X] **BG** Bulgaria .....
- [X] **BR** Brazil .....
- [X] **BY** Belarus
- [X] **CA** Canada
- [X] **CH and LI** Switzerland and Liechtenstein
- [X] **CN** China .....
- [X] **CZ** Czech Republic .....
- [X] **DE** Germany .....
- [X] **DK** Denmark .....
- [X] **EE** Estonia .....
- [X] **ES** Spain .....
- [X] **FI** Finland .....
- [X] **GB** United Kingdom
- [X] **GE** Georgia .....
- [X] **HU** Hungary .....
- [X] **IS** Iceland
- [X] **JP** Japan .....
- [X] **KE** Kenya .....
- [X] **KG** Kyrgyzstan .....
- [X] **KP** Democratic People's Republic of Korea .....
- [X] **KR** Republic of Korea .....
- [X] **KZ** Kazakhstan .....
- [X] **LK** Sri Lanka
- [X] **LR** Liberia
- [X] **LT** Lithuania
- [X] **LU** Luxembourg .....
- [X] **LV** Latvia
- [X] **MD** Republic of Moldova .....
- [X] **MG** Madagascar .....
- [X] **MN** Mongolia
- [X] **MW** Malawi .....
- [X] **MX** Mexico .....
- [X] **NO** Norway
- [X] **NZ** New Zealand .....
- [X] **PL** Poland .....
- [X] **PT** Portugal .....
- [X] **RO** Romania
- [X] **RU** Russian Federation .....
- [X] **SD** Sudan
- [X] **SE** Sweden
- [X] **SG** Singapore
- [X] **SI** Slovenia .....
- [X] **SK** Slovakia .....
- [X] **TJ** Tajikistan .....
- [X] **TM** Turkmenistan .....
- [X] **TT** Trinidad and Tobago .....
- [X] **UA** Ukraine .....
- [X] **UG** Uganda .....
- [X] **US** United States of America .....
- [X] **UZ** Uzbekistan .....
- [X] **VN** Viet Nam .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- [X] MK Macedonië .....
- [ ] .....
- [ ] .....
- [ ] .....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of _____.

The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

See Notes to the request form

Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country *(in which, or for which, the application was filed)*	Filing Date *(day/month/year)*	Application No.	Office of filing *(only for regional or international application)*
item (1) NL	04. 10. 1994 04 oktober 1994	9401632	
item (2)			
item (3)			

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☐ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s) : _____

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA / EP

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been carried out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. Identify such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request:*

Country (or regional Office):	Date *(day/month/year)*:	Number:
NL	28 June 1994	SN 24966 NL

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	4	sheets
2. description	14	sheets
3. claims	6	sheets
4. abstract	1	sheets
5. drawings	3	sheets
Total	28	sheets

This international application is accompanied by the item(s) marked below:

1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing (diskette)
8. ☐ other *(specify)*:

Figure No. 1 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

J. A. M. J. H. Vossen

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority specified by the applicant: ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

SMULDERS, Th., A., H., J.
Vereenigde Octrooibureaux
Nieuwe Parklaan 97
NL-2587 BN The Hague
PAYS-BAS

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
03 November 1995 (03.11.95)	
Applicant's or agent's file reference	**International application No.**
PCT 0413	PCT/NL95/00335

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

FANCOM B.V. (for all designated States except US)
BERCKMANS, Daniel et al (for US)

International filing date	:	03 October 1995 (03.10.95)
Priority date(s) claimed	:	04 October 1994 (04.10.94)
Date of receipt of the record copy by the International Bureau	:	03 November 1995 (03.11.95)
List of designated Offices	:	

AP :KE,MW,SD,SZ,UG
EP :AT,BE,CH,DE,DK,ES,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,ML,MR,NE,SN,TD,TG
National :AM,AT,AU,BB,BG,BR,BY,CA,CH,CN,CZ,DE,DK,EE,ES,FI,GB,GE,HU,IS,JP,KE,KG,KP, KR,KZ,LK,LR,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,TJ,TM,TT, UA,UG,US,UZ,VN

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase;
- [ ] confirmation of precautionary designations;
- [X] requirements regarding priority documents.

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

Peggy Steunenberg

Telephone No. (41-22) 730.91.11

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OF PRIORITY DOCUMENTS

(PCT Administrative Instructions, Section 411)

To:

SMULDERS, Th., A., H., J.
Vereenigde Octrooibureaux
Nieuwe Parklaan 97
NL-2587 BN The Hague
PAYS-BAS

Date of mailing (day/month/year) 31 January 1996 (31.01.96)		
Applicant's or agent's file reference PCT 0413		IMPORTANT NOTIFICATION
International application No. PCT/NL95/00335	International filing date (day/month/year) 03 October 1995 (03.10.95)	Priority date (day/month/year) 04 October 1994 (04.10.94)
Applicant FANCOM B.V. et al		

The applicant is hereby notified of the date of receipt by the International Bureau of the priority document(s) relating to the following application(s):

Priority application No:	Priority date:	Priority country:	Date of receipt of priority document:
9401632	04 Oct 1994 (04.10.94)	NL	25 Jan 1996 (25.01.96)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

K. Andreasson

Telephone No.: (41-22) 730.81.11

Form PCT/IB/304 (July 1992)

000975111

WO 96/10733
PCT/NL95/00335

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

4-4-97 nat/reg. fase

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

- 1 MEI 1996

Date of mailing (day/month/year)
11 April 1996 (11.04.96)

Applicant's or agent's file reference
MAPCT 0413

To:

SMULDERS, Th., A., H., J.
Vereenigde Octrooibureaux
Nieuwe Parklaan 97
NL-2587 BN The Hague
PAYS-BAS

IMPORTANT NOTICE

International application No.	International filing date	Priority date
PCT/NL95/00335	03 October 1995 (03.10.95)	04 October 1994 (04.10.94)

Applicant

FANCOM B.V. et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:

   AT,AU,BR,CA,CN,CZ,DE,EP,FI,GB,JP,KP,KR,LK,NO,NZ,PL,RO,RU,SK,US

2. In accordance with Rule 47.1(c), third sentence, each designated Office will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Offices.

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on

   11 April 1996 (11.04.96) under No. WO 96/10733

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for internationl preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14

Authorized officer:

J. Zahra

Telephone No.: (41-22) 730.91.11

Continuation of Form PCT/IB/308

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

Date of mailing (day/month/year) 11 April 1996 (11.04.96)	**IMPORTANT NOTICE**
Applicant's or agent's file reference PCT 0413	**International application No.** PCT/NL95/00335

The designated Office(s) of:

AM,AP,BB,BG,BY,CH,DK,EE,ES,GE,HU,IS,KE,KG,KZ,LR,LT,LU,LV,MD,MG,MK,MN,MW,MX,OA,PT, SD,SE,SG,SI,TJ,TM,TT,UA,UG,UZ,VN

has (have) waived the requirement for such a communication, but nevertheless a copy of the international application need not be furnished by the applicant to the Office(s) concerned.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

SMULDERS, Th., A., H., J.
Vereenigde Octrooibureaux
Nieuwe Parklaan 97
NL-2587 BN The Hague
PAYS-BAS

Date of mailing:
02 May 1996 (02.05.96)

Applicant's or agent's file reference:
PCT 0413

IMPORTANT INFORMATION

International application No.:	International filing date:	Priority date:
PCT/NL95/00335	03 October 1995 (03.10.95)	04 October 1994 (04.10.94)

Applicant:
FANCOM B.V. et al

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

AP :KE,MW,SD,SZ,UG
EP :AT,BE,CH,DE,DK,FR,GB,IE,IT,LU,MC,NL,PT,SE
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The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of the annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

The entry into the European regional phase is postponed until 31 months from the priority date for all States designated for the purposes of obtaining a European patent including, where applicable, ES and GR which cannot be elected since they are not bound by Chapter II.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer:
Beate Schmitt
Telephone No.: (41-22) 730.81.11

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PCT 0413		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL 95/ 00335	03/10/1995	04/10/1994
International Patent Classification (IPC) or national classification and IPC		
G01F1/10		
Applicant		
FANCOM B.V. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consists of a total of _____ sheets.

3. This report contains indications and corresponding pages relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
19/04/1996	18.06.96
Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	B. Fenzl
	Telephone No.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

I. Basis of the report

1. This report has been drawn up on the basis of (Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.):

[x] the international application as originally filed.

[ ] the description, pages _____, as originally filed,
pages _____, filed with the demand,
pages _____, filed with the letter of _____,
pages _____, filed with the letter of _____,

[ ] the claims, Nos. _____, as originally filed,
Nos. _____, as amended under Article 19,
Nos. _____, filed with the demand,
Nos. _____, filed with the letter of _____,
Nos. _____, filed with the letter of _____,

[ ] the drawings, sheets/fig _____, as originally filed,
sheets/fig _____, filed with the demand,
sheets/fig _____, filed with the letter of _____,
sheets/fig _____, filed with the letter of _____.

2. The amendments have resulted in the cancellation of:
[ ] the description, pages _____.
[ ] the claims, Nos. _____.
[ ] the drawings, sheets/fig _____.

3. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims 1-19	YES
	Claims	NO
Inventive Step (IS)	Claims 1-19	YES
	Claims	NO
Industrial Applicability (IA)	Claims 1-19	YES
	Claims	NO

2. CITATIONS AND EXPLANATIONS

The object of the invention is to provide a flow sensor which has a good measuring characteristic at low flow rates and/or great pressure differences and which is pressure-independent.

This object is achieved by the features of the independent claims 1, 14, 15 and 17 where formulae are given how to configure the blade angle of the impeller of the flow sensor.

None of the search report documents is concerned with the problem of configuring blade angles. The invention is new and not rendered obvious by these documents.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:
SMULDERS, Th.A.H.J.
VEREENIGDE OCTROOIBUREAUX
Nieuwe Parklaan 97
2587 BN DEN HAAG
PAYS-BAS

4-4-97 nat./reg. fase

16 JUN 1996

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Applicant's or agent's file reference: PCT 0413	Date of mailing (day/month/year): 18.06.96
	IMPORTANT NOTIFICATION

International application No.	International filing date (day/month/year)	Priority date (day/month/year)
PCT/NL 95/00335	03/10/1995	04/10/1994

Applicant

FANCOM B.V. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	C. Perrinelle Telephone No. 2399/2835

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

United States Patent and Trademark Office
(Box PCT)
Washington D.C. 20231
United States of America

in its capacity as elected Office

Date of mailing (day/month/year) 02 May 1996 (02.05.96)	
International application No. PCT/NL95/00335	**Applicant's or agent's file reference** PCT 0413
International filing date (day/month/year) 03 October 1995 (03.10.95)	**Priority date** (day/month/year) 04 October 1994 (04.10.94)
Applicant BERCKMANS, Daniel et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

19 April 1996 (19.04.96)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Beate Schmitt
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 730.91.11

PATENT COOPERATION TREATY

REC'D 19 JUN 1996
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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PCT 0413		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL 95/ 00335	03/10/1995	04/10/1994
International Patent Classification (IPC) or national classification and IPC		
G01F1/10		
Applicant		
FANCOM B.V. et al.		

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   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
19/04/1996	18.06.96
Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	B. Fenzl
	Telephone No.

Form PCT/IPEA/409 (cover sheet) (January 1994) (13/05/1996)

Intern. application No.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

PCT/NL95/00335

I. Basis of the report

1. This report has been drawn up on the basis of (Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.):

[x] the international application as originally filed.

[ ] the description, pages _____, as originally filed,
pages _____, filed with the demand,
pages _____, filed with the letter of _____,
pages _____, filed with the letter of _____,

[ ] the claims, Nos. _____, as originally filed,
Nos. _____, as amended under Article 19,
Nos. _____, filed with the demand,
Nos. _____, filed with the letter of _____,
Nos. _____, filed with the letter of _____,

[ ] the drawings, sheets/fig _____, as originally filed,
sheets/fig _____, filed with the demand,
sheets/fig _____, filed with the letter of _____,
sheets/fig _____, filed with the letter of _____.

2. The amendments have resulted in the cancellation of:
[ ] the description, pages _____.
[ ] the claims, Nos. _____.
[ ] the drawings, sheets/fig _____.

3. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. STATEMENT

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	Claims	NO
Inventive Step (IS)	Claims 1-19	YES
	Claims	NO
Industrial Applicability (IA)	Claims 1-19	YES
	Claims	NO

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The object of the invention is to provide a flow sensor which has a good measuring characteristic at low flow rates and/or great pressure differences and which is pressure-independent.

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None of the search report documents is concerned with the problem of configuring blade angles. The invention is new and not rendered obvious by these documents.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01F 1/10, 25/00, F24F 11/00	A1	**(11) International Publication Number:**	**WO 96/10733**
		(43) International Publication Date:	11 April 1996 (11.04.96)

(21) International Application Number: PCT/NL95/00335

(22) International Filing Date: 3 October 1995 (03.10.95)

(30) Priority Data:
9401632 4 October 1994 (04.10.94) NL

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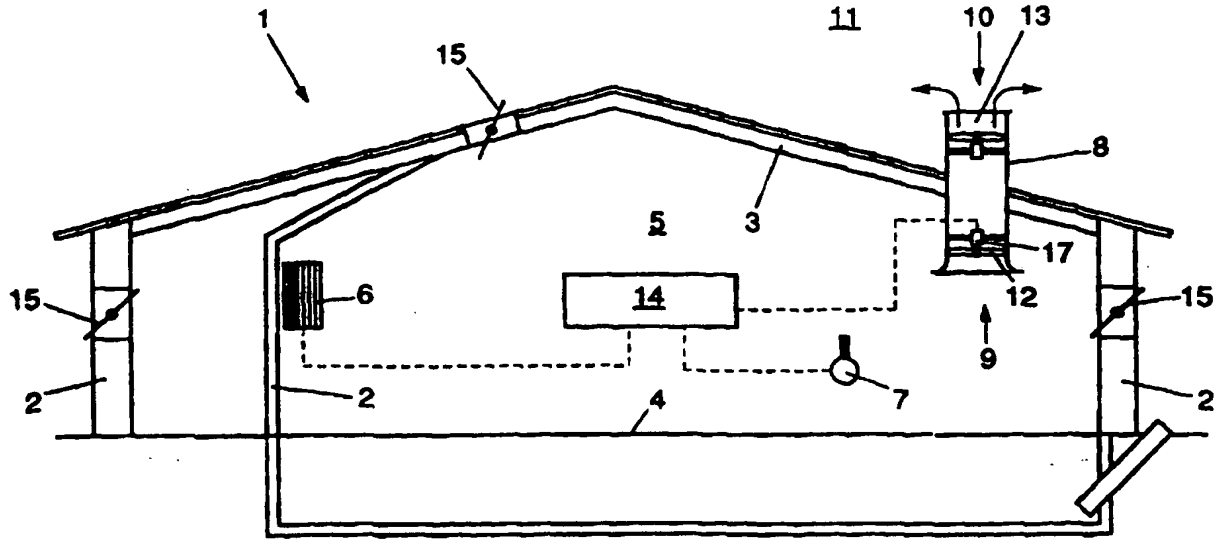
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Dutch).

(54) Title: FLOW SENSOR



(57) Abstract

A flow sensor, in particular suitable for use in air flow measuring, comprising an impeller which is suspended for free rotation in a tube section and which comprises a central core and a number of blades extending from the core, at least one blade extending from the core to adjacent the inner wall of the tube section, measuring means being included for measuring the number of revolutions of the impeller per unit of time, the flow sensor being adapted to register, when a calibration flow rate is passed through the tube, an associated calibration speed of the impeller by means of the measuring means.

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GA	Gabon				

Title: Flow sensor

The invention relates to a flow sensor, in particular suitable for use in air flow measuring, comprising an impeller suspended for free rotation in a tube section.

With known flow sensors of the above-mentioned type, a fan impeller is for instance used as impeller, arranged in a tube section so as to be freely rotatable therein. The rotations of the impeller are measured, whereupon the flow rate through the tube section is determined with some precision. With the known flow sensors, the relation between a measured speed and the flow rate through the tube section is not linear and moreover depends on the pressure drop over the measuring system. In particular at low speeds and small flow rates, and at great pressure differences over the tube section, a highly deviant behavior may be created.

A fan impeller is designed so that a rotation energy can thereby be converted into an air movement. The number of blades and the blade configuration of the fan impeller are selected to that end. When such a fan impeller is employed as a freely rotating fan impeller, i.e. a fan impeller not driven by means of a motor or a like means, the relation between the rotary speed and the flow rates through the surface covered by the impeller will deviate substantially from a linear relation, in particular at low speeds and/or great pressure differences between the two sides of the impeller, and will moreover be directly dependent on the pressure difference over the tube section.

At low speeds and great pressure differences, air will be led back through the impeller, the so-called back-flow, which causes the rotary speed of the impeller to be changed at a constant flow rate, for instance as a result of an adjacently disposed ventilating fan. Moreover, a fan impeller typically causes strong air turbulences, which also causes the action of the flow sensor to be adversely affected. This means that such flow sensors have a poor measuring characteristic, in particular at low flow rates, and that these known flow sensors are in particular not pressure-independent.

The object of the invention is to provide a flow sensor of the type described in the opening paragraph, wherein the drawbacks mentioned are avoided while the advantages are maintained. To that end, the flow sensor according to the invention is characterized by the features of claim 1.

The blade angles of the different cross sections of the blades of the impeller of the flow sensor according to the invention provide a flow sensor having an almost pressure-independent measuring characteristic within the measuring range of the flow sensor. The calibration combination to be referred to as design couple, consisting of a calibration flow rate and a calibration speed can be selected so that this measuring characteristic can readily be adapted to the measuring means and further means, if any, for the processing of the registered speeds of the impeller during use. The characteristic, given according to the invention, of the curve of the blade angles over the blades of the impeller offers the advantage that, starting from a design couple suitable for the desired use and from a suitable tube section diameter, a substantially pressure-independent flow sensor can always be obtained, i.e. for any application a flow sensor can be designed having a substantially linear measuring characteristic, which measuring characteristic comprises at least the design couple selected. Owing to its construction, in particular in combination with a suitable material selection, the flow sensor is suitable for use in dusty and corrosive environments, at strongly varying temperatures and at different humidities. The flow sensor can be used for gas flow measurement, but is also suitable for use in fluid flow measurement.

A flow sensor according to the invention is in particular suitable for use in industrial, agricultural and civil utilizations in respect of air conditioning, process control, emission control, emission measurement in practical circumstances and the like.

A further elaboration of the flow sensor according to the invention is characterized by the features of claim 2.

When a flow sensor with a freely-rotating impeller is used, it is important that the speed of the impeller during use remains within given limits at a minimum and maximum flow rate to be measured, so as to preclude disturbances of the measuring characteristic. At unduly high speeds, movements of the blades will result in an erratic behavior of the impeller, which adversely affects the measuring precision and the sensitivity. Moreover, at unduly high speeds of the impeller, unacceptable noise production and wear occur. At unduly low speeds, the measuring precision of the flow sensor becomes too low.

In order to obtain a better measuring behavior of the flow sensor within the desired measuring range, the flow sensor is preferably characterized by the features of claim 3.

In a particularly advantageous embodiment, the flow sensor according to the invention is characterized by the features of claims 4 and 5.

By providing the impeller with two, preferably diametrically opposite blades, a stable impeller is obtained which can be bearing-mounted in a simple manner, because only minimum forces are exerted on the bearing. After all, unlike the impeller of the known flow sensors, the impeller according to the invention is not designed for the transfer of energy. Only the friction of the bearing needs to be overcome. Moreover, only a very small part of the frontal surface of the tube section is covered by a stationary impeller. Owing to these measures, the flow resistance, and accordingly the impact of the impeller on the flow pattern in the tube section are minimal. Because the blades extend to adjacent the inner wall of the tube section, the entire tube section is covered during one revolution of the impeller. With the impeller according to the invention, this has the advantage of rendering the motional pattern thereof independent of the flow pattern in the tube section. The flow sensor according to the invention can be used with both turbulent and laminar flow in the tube section without affecting the measuring

characteristic, while in each case, the flow sensor keeps functioning accurately.

In an alternative embodiment, the flow sensor is characterized by the features of claim 9.

By disposing a ventilating fan in the tube section, a compact device is obtained which can easily be installed, while the impeller and the ventilating fan can be adjusted to each other in an optimum manner. Arrangement of the ventilating fan downstream of the impeller results in a high accuracy of the flow sensor.

In this connection, it is particularly advantageous if the flow sensor is also characterized by the features of claim 10.

The opposite directions of rotation of the ventilating fan and the impeller produces an advantageous flow pattern within the tube section, which prevents disadvantageous disturbances of the measuring characteristic, for instance caused by undesired vibrations.

The invention further relates to an impeller of the type set forth in the preamble of claim 14, which impeller according to the invention is characterized by the features of the characterizing part of claim 14.

Such an impeller can particularly advantageously be arranged within a tube section and is then suitable for use with a flow sensor, because it has substantially a pressure-independent rotation characteristic. The impeller can easily be adapted to the diameter of a suitable tube section, in such a manner that at one rotation of the impeller within the tube section, substantially the entire cross section of that tube section is covered by the blades.

The invention moreover relates to a ventilating device, in particular suitable for use for the ventilation of spaces, and to a method for the manufacture of a flow sensor, comprising a freely-rotating impeller disposed in a tube section.

To explain the invention, exemplary embodiments of a flow sensor and a ventilating device will hereinafter be

described with reference to the accompanying drawings, wherein:

Fig. 1 is a sectional view of a stable comprising a ventilating device;

Fig. 2 is a partially sectional side elevation of a flow sensor according to the invention;

Fig. 3 is a sectional view of an impeller taken on the line III-III in Fig. 2;

Fig. 4 schematically shows the bottom side of a blade cross section according to Fig. 3; and

Fig. 5 is a front view of an impeller.

Fig. 1 shows a stable 1 comprising an inner space 5 defined by a number of walls 2, a roof 3 and a floor 4. Provided in the inner space 5 are heating means 6 and measuring means 7 for determining the composition of the air in the inner space 5. Provided in the roof 3 is a tube section 8 communicating by a first open end 9 with the inner space 5 and connecting by the opposite, second open end 10 to the outer space 11 of the stable 1. In the tube section 8, which has a circular inner section, an impeller 12 is freely rotatably suspended adjacent the inwardly facing first open end 9, which impeller 12 will be further discussed hereinafter. Adjacent the second open end 10, a ventilating fan 13 is disposed in the tube section, by means of which ventilating fan air can be discharged from the inner space 5 to the outer space 11 via the tube section 8.

The heating means 6, the air composition-measuring means 7, the impeller 12 and the ventilating fan 13 are all connected to a control unit 14, for instance a computer-controlled regulating unit. Also connected to the regulating unit 14 are controlled ventilation-regulating valves 15 in the walls 2, the roof 3 and/or the floor 4. On the basis of the air composition measured, the ventilation-regulating valves 15 are controlled into the open and closed positions, the ventilating fan 13 being controlled in such a manner that a desired air flow, necessary for freshening the air in the inner space 5, is discharged through the tube section 8. In

this connection, it is important that the air flow discharged is accurately determined and regulated to obtain an optimum ventilation of the inner space 5, without for instance wasting unduly much heat and without causing draft.

The impeller 12 comprises two blades 16, disposed diametrically opposite each other and attached to a core 30 which is bearing-mounted in a housing 32 so as to be smooth-running, which housing is centrally suspended within the tube section by means of a number of radial spokes 33. The core 30 has a small frontal surface and is aerodynamically shaped, so that the flow pattern of the air within the tube section 8 is minimally affected by the core 30. The axis of rotation S of the impeller 12 coincides with the longitudinal axis of the tube section 8. The blades 16 extend to near the inner wall of the tube section 8. The distance between the inner wall of the tube section 8 and the free end of the blade 16 is less than 2% of the diameter of the tube section, and is preferably approximately 1%. Accordingly, almost the entire cross section of the tube section is covered by the blades 16 during use, enabling the flow sensor to be used both in the case of turbulent flow and in the case of laminar flow in the tube section. Preferably, the direction of rotation of the impeller is opposite to the direction of rotation of the ventilating fan.

In the embodiment shown, the tube section is at its first open end 9 provided with an outwardly bent inflow edge 31 whose curvature radius R is greater than 10% of the diameter D of the tube section. The impeller is preferably disposed either at the level of the inflow edge 31 or at a distance from the inflow edge 31 which is at least half the diameter D of the tube section 8. By using of one of these configurations, influence of the inflow pattern of the air in the tube section 8 on the measuring characteristic of the flow sensor is prevented. Further, for that purpose, the impeller 12 and the ventilating fan 13 are spaced apart a distance at least corresponding to the diameter D of the tube section 8.

For measuring the flow rate through the tube section 8, the impeller 12 comprises measuring means 17 for determining the speed of the impeller 12. The speed measured is an indication for the flow rate on the basis of which for instance the rotary speed of the ventilating fan 13 can be adjusted, the position of the different regulating valves 15 can be accommodated and the heating 6 can be readjusted, by means of the regulating unit 14.

To enable the flow rate to be calculated from the speed of the impeller 12 in a cheap and reliable manner, it is important that there is a linear relation between the flow rate and the speed measured, regardless of pressure differences between the inner space 5 and the outer space 11 and regardless of the flow pattern within the tube section 8. This linear relation is substantially determined by the configuration of the impeller 12, and in particular by the blade configuration.

For this purpose, to the blades 16 of the impeller 12, as shown in Fig. 2, it applies that the blade angle H of each section meets the equation

$$[tg(H(r)) * Caldeb * C]/[r * D^2] = Calrev \quad [1]$$

wherein

r = distance section relative to the center of the core (m);
H(r) = blade angle of section at distance r (°);
Caldeb = calibration flow rate (m^3/h)
Calrev = calibration speed (rev/min)
D = diameter tube section (m)

wherein C lies between 0.003 and 0.004 and is preferably 6.67/1974. In practice, the blade angle preferably differs maximally 3° from the optimum blade angle.

The blade angle H is defined as the angle included by the blade 16 with the axis of rotation S of the impeller 12, as is shown in Fig. 3.

For calculating the suitable configuration for the blades 16, a calibration combination K is started from, which can be referrred to as a design couple suitable for the

application and consists of a calibration flow rate Caldeb and an associated calibration speed Calrev. The design couple K is inter alia selected on the basis of the regulating unit 14 and the speed-measuring means 17 to be used, and forms a point on the measuring characteristic of the flow sensor. As an example, Table 1 shows the blade angles of an impeller 12 which is pressure-independent, and hence particularly suitable for use in a flow sensor according to the invention.

Table 1

Caldeb	500 m^3/h	Maxdeb	8,000 m^3/h
Calrev	125 rev/min	Maxrev	2,000 rev/min
D	0.45 m	Mindeb	120 m^3/h
C	0.0034	Minrev	30 rev/min

r (m)	H(r) (°)	B (m)
0.05	36.8	0.100
0.06	42.0	
0.07	46.4	
0.08	50.2	
0.09	53.4	
0.10	56.3	0.061
0.11	58.8	
0.12	60.9	
0.13	62.8	
0.14	64.5	
0.15	66.0	0.051
0.16	67.4	
0.17	68.6	
0.18	69.7	
0.19	70.6	
0.20	71.5	0.047
0.21	72.4	

Subsequently, for a further optimization of the flow sensor, and in particular the impeller 12, for at least the larger part of each blade 16, a suitable blade width B is determined for each section, meeting the equation

$$[r_1*\cos(H_1)*B_1]/[r_2*\cos(H_2)*B_2]>1 \quad [2]$$

wherein:

r_1 = distance first section relative to the center of the core (m);

r_2 = distance second section relative to the center of the core (m);

wherein $r_2 > r_1$;

H_1 = blade angle first section (°);

H_2 = blade angle second section (°);

B_1 = Blade width first section (m); and

B_2 = Blade width second section (m),

wherein to all blade angles of the impeller it applies that they lie in one quadrant and the the blade angle H and blade width B have a flowing curve over the blade. For the use of the impeller in an air flow sensor in a situation as shown in Fig. 1, the width of the blade should preferably be between 1 and 15 cm. For the embodiment described in Table 1, a blade width B of 10 cm at a distance of 5 cm is started from. The curve of the width over the blade is shown in Table 1 in the right-hand column. In the embodiment shown, the core has a diameter of approximately 10 cm.

In the case of air flow measurement by means of a freely rotating impeller, the speed should preferably be kept within a specific range. Unduly high speeds of the impeller 12 involve a great chance of instability of the blades 16 of the impeller, which adversely affects the measuring characteristic. Moreover, this causes substantial wear of the different components of the device and an unpleasant noise level. At unduly low speeds, the measuring accuracy of the flow sensor is too easily adversely affected.

Given a maximum and minimum allowable speed, a maximum and minimum measurable flow rate can be determined for each impeller 12 on the basis of the equations

$$[tg(H(r)_{max}) * Maxdeb * C]/[r * D^2] < Maxrev \quad [3]$$

and

$$[tg(H(r)_{min}) * Mindeb * C]/[r * D^2] < Minrev \quad [4]$$

wherein:

$H(r)_{max}$ = maximum blade angle section at distance r (°);

$H(r)_{min}$ = minimum blade angle section at distance r (°);

Maxdeb = maximum measuring flow rate (m^3/h)

Mindeb = minimum measuring flow rate (m^3/h)

Maxrev = maximum measuring speed (rev/min)

Minrev = minimum measuring speed (rev/min)

By filling in a blade angle H and the maximum allowable speed in the upper equation *[3]*, the maximum measurable flow rate can easily be determined, by filling in the blade angle H and the minimum allowable speed in the lower equation *[4]*, the minimum measurable flow rate can easily be determined.

Conversely, on the basis of the same equations *[3]*, *[4]*, it is also possible to calculate a maximum allowable blade angle for each section on the basis of the maximum flow rate to be measured and the maximum allowable speed therefor, and, likewise, to calculate a minimum blade angle for each section by filling in a minimum flow rate to be measured and a minimum speed required therefor. This offers the possibility of determining, prior to the determination of the blade angles for an impeller 12, the design limits on the basis of which a favorable calibration combination K can be selected. Table 2 shows the maximum and minimum blade angle $H(r)_{max}$, $H(r)_{min}$ for the different sections for an impeller, starting from the design criteria given in the heading of Table 2.

Table 2

Maxdeb	6,000 m^3/h
Maxrev	2,000 r/min
Mindeb	200 m^3/h
Minrev	30 r/min
D	0.45 m
C	0.0034

radius m	min. angle (°)	max. angle (°)
0.05	24.2	45
0.06	28.3	50.2
0.07	32.2	54.4
0.08	35.7	58
0.09	39	60.9
0.10	42	63.4
0.11	44.7	65.5
0.12	47.2	67.4
0.13	49.4	68.9
0.14	51.5	70.3
0.15	53.4	71.5
0.16	55.2	72.6
0.17	56.8	73.6
0.18	58.3	74.5
0.19	59.7	75.2
0.20	60.9	76
0.21	62.1	76.6
0.22	63.2	77.2
0.23	64.2	77.7
0.24	65.1	78.2
0.25	66	78.7
0.26	66.8	79.1
0.27	67.6	79.5
0.28	68.3	79.9

When a design couple K has been selected, the optimum blade angles H can be determined by filling in the first equation *[1]*. If it appears that the blade angles H found lie too much outside the limit values found with the third and fourth equations *[3]*, *[4]*, an adjusted design couple K can be selected. In this manner, the curve of the blade angles can easily be optimized. Next, for each blade section the width can be determined on the basis of the second equation *[2]*, in such a manner that the blade configuration meets the requirements set and is hence pressure-independent and provides a desired, linear measuring characteristic of a suitable accuracy.

Fig. 3 shows a cross section of a blade 16 of an impeller 12. The blade 16 has a front side 18, a rear side 19, a leading side 20 and a bent top side 21. In the embodiment shown, the leading side 20 is substantially flat, which has a positive influence on the pressure-independence of the impeller. The curvature of the blade, given by the difference between the inflow angle $ß_1$ and the outflow angle $ß_2$, as shown in Fig. 4, is less than 5°, and preferably about 0°. The maximum thickness of the blade is about 10% of the blade width, and is located at about 1/3 of the blade width, measured from the front side 18 of the blade 16. The blade angle H corresponds to the average of the inflow angle $ß_1$ and the outflow angle $ß_2$.

Fig. 5 shows an impeller 40 suitable for use in a flow sensor which is pressure-independent. The blade angles H_1, H_2 of two sections at different distances r_1, r_2 from the core 30 meet the equation

$$(r_2/r_1)*\tan(H_1)=\tan(H_2) \qquad [5]$$

wherein

r_1 = distance first section relative to the center of the core (m);

r_2 = distance second section relative to the center of the core (m);

H_1 = blade angle first section (°);

H_2 = blade angle second section (°).

Starting from such an impeller 40, a flow sensor can be assembled in a simple manner which is almost pressure-independent. For that purpose, a suitable tube section diameter D can for instance be determined starting from a selected blade angle for one of the cross sections of a blade 41 and a suitable design couple K by filling in these values in the first equation *[1]*. Then, the length L of the blades 41 can be adjusted to that tube section. When the values found and a maximum allowable speed are filled in in the second equation *[2]*, an upper limit for the measuring range of the flow meter is then given, and, similarly, when the third equation *[3]* is filled in, a lower limit is given. Since the flow sensor has a linear measuring characteristic, it can readily be determined whether this maximum speed therefor will actually occur. When this threatens to be exceeded, a different calibration combination will have to be selected to which, accordingly, a different diameter of the tube section will be associated. In this manner, the suitable configuration of a pressure-independent flow sensor having the desired measuring range can in each case be obtained, starting from the impeller 40. Of course, starting from a design couple, it is also possible to determine for each tube section diameter the suitable blade angle by filling in the found values in equation *[1]*.

With a method according to the invention a flow sensor can be obtained which can be used in, for instance, agricultural, industrial and civil applications for use in air conditioning, process control, emission measurement, and the like. The flow sensor can be used for, for instance, air and fluid flow measurement in corrosive and dusty environments, at different temperatures and degrees of humidity.

The flow sensor can be designed for measuring flow rates of between 200 and 6000 m^3/h, but greater and smaller flow rates are also possible. The blade length of the impeller can at least vary between 15 and 40 cm, but greater and smaller blade lengths are also possible. The flow sensor according to the invention is at least usable at pressure

differences between 0 and 120 Pa, and can achieve a measuring accuracy of approximately 60 m^3/h or less over the selected measuring range. Of course, the invention is not limited to the embodiments as shown by way of example. Many variations are possible within the purview of the invention.

For instance, the impeller may be provided with a different number of blades and the flow sensor may be used without ventilating fan, for instance in the case of natural ventilation. Other sensors may be connected to the regulating unit, such as for instance mechanical switches and time switches.

In the regulating unit different regulating programs may be included, adapted to control a process wherein the flow sensor is included.

Starting from one of more of the parameters given, the flow sensor or the impeller according to the invention can in each case be optimally adjusted to the process to be controlled. In this connection, the selection of the magnitude of the parameters is understood to fall within the scope of anyone skilled in the art.

CLAIMS

1. A flow sensor, in particular suitable for use in air flow measuring, comprising an impeller which is suspended for free rotation in a tube section and which comprises a central core and a number of blades extending from the core, wherein at least one blade extends from the core to adjacent the inner wall of the tube section, wherein measuring means are included for measuring the number of revolutions of the impeller per unit of time, wherein the flow sensor is adapted to register, when a calibration flow rate is passed through the tube, an associated calibration speed of the impeller by means of the measuring means, wherein to at least a series of cross sections of the blade it applies that the blade angle substantially meets the formula

$$[tg(H(r)) * Caldeb * C]/[r * D^2] = Calrev$$

wherein

r = distance section relative to the center of the core (m);
H(r) = blade angle of section at distance r (°);
Caldeb = calibration flow rate (m^3/h)
Calrev = calibration speed (rev/min)
D = diameter tube section (m)

wherein $0.003 < C < 0.004$ and C is preferably 6.67/1974.

2. A flow sensor according to claim 1, characterized in that to each cross section of the blade it applies that the blade angle substantially meets the formulae

$$[tg(H(r)_{max}) * Maxdeb * C]/[r * D^2] < Maxrev$$

and

$$[tg(H(r)_{min}) * Mindeb * C]/[r * D^2] < Minrev$$

wherein:

$H(r)_{max}$ = maximum blade angle section at distance r (°);
$H(r)_{min}$ = minimum blade angle section at distance r (°);
Maxdeb = maximum measuring flow rate (m^3/h)
Mindeb = minimum measuring flow rate (m^3/h)
Maxrev = maximum measuring speed (rev/min)
Minrev = minimum measuring speed (rev/min)

3. A flow sensor according to claim 1 or 2, characterized in that to substantially each combination of two cross sections of the blade it applies that

$$[r_1*\cos(H_1)*B_1]/[r_2*\cos(H_2)*B_2]>1$$

wherein:

r_1 = distance first section relative to the center of the core (m);

r_2 = distance second section relative to the center of the core (m);

wherein $r_2 > r_1$;

H_1 = blade angle first section (°);

H_2 = blade angle second section (°);

B_1 = Blade width first section (m); and

B_2 = Blade width second section (m),

wherein to all blade angles of the impeller it applies that they lie in one quadrant and that the blade angle (H) and blade width (B) have a flowing curve over the blade.

4. A flow sensor according to any one of the preceding claims, characterized in that the impeller comprises two blades which together with the core cover the entire diameter of the relevant cross section of the tube section, the blades preferably being arranged diametrically opposite each other.

5. A flow sensor according to any one of the preceding claims, characterized in that the distance between the free end of the or each blade and the inner wall of the tube section is less than 2%, and preferably approximately 1% of the diameter of the tube section.

6. A flow sensor according to any one of the preceding claims, characterized in that for each blade the blade curve at the leading side is less than 5°, and preferably approximately 0°.

7. A flow sensor according to any one of the preceding claims, characterized in that to a cross section of each blade it applies that the cross section has the greatest thickness at a distance of about 1/3 of the blade width, measured from the front edge of the blade, the greatest blade thickness being preferably about 10% of the relevant blade width.

8. A flow sensor according to any one of the preceding claims, characterized in that the core has a frontal surface of no more than approximately 10% of the internal cross section of the tube section.

9. A flow sensor according to any one of claims 1-8, characterized in that in the tube section, downstream of the impeller, a ventilating fan is arranged for drawing in air, via the tube section, from the side of the impeller remote from the ventilating fan and through the plane covered by the impeller during a revolution, and for delivering said air outside the tube section.

10. A flow sensor according to claim 9, characterized in that during use, the ventilating fan rotates in a direction opposite to that of the impeller.

11. A flow sensor according to claim 9 or 10, characterized in that the distance between the blades of the ventilating fan and the blades of the impeller at least corresponds to the diameter of the tube section.

12. A flow sensor according to any one of claims 9-11, characterized in that on the side of the impeller, the tube section comprises an outwardly bent inflow edge whose curvature radius is greater than 10% of the diameter of the tube section, the impeller being disposed at the level of the inflow edge.

13. A flow sensor according to any one of claims 9-11, characterized in that on the side of the impeller, the tube section comprises an outwardly bent inflow edge whose curvature radius is greater than 10% of the diameter of the tube section, the impeller being disposed at a distance from the inflow edge which is at least half the diameter of the tube section.

14. A ventilating device, in particular suitable for use for the ventilation of spaces, wherein a flow sensor according to any one of the preceding claims is included in one of the boundaries of a space to be ventilated, wherein switching means are included for regulating, on the basis of the speeds of the impeller registered by the measuring means and an air

composition measured within the space, the amount of air to be discharged from the space by the flow sensor.

15. An impeller for arrangement in a tube section, comprising a central core and a number of blades extending from the core, characterized in that to substantially each combination of two cross sections of the blade it applies that the blade angles meet the equation

$$(r_2/r_1)*\tan(H_1)=\tan(H_2)$$

wherein

r_1 = distance first section relative to the center of the core (m);

r_2 = distance second section relative to the center of the core (m);

H_1 = blade angle first section (°);

H_2 = blade angle second section (°).

16. An impeller according to claim 15, characterized in that there is a calibration combination of a calibration flow rate and a calibration speed wherein to substantially each cross section of the blade it applies that the blade angle meets the formula

$$[\mathrm{tg}(H(r)) * \mathrm{Caldeb} * C]/[r * D^2] = \mathrm{Calrev}$$

wherein

r = distance section relative to the center of the core (m);

H(r) = blade angle at distance r (°);

Caldeb = calibration flow rate (m^3/h)

Calrev = calibration speed (rev/min)

D = diameter intended tube section (m)

wherein $0.003 < C < 0.004$ and C is preferably 6.67/1974.

17. A method for the manufacture of a flow sensor, comprising an impeller disposed in a tube section, said impeller having at least a core, a number of blades extending from the core, core bearing means, means for securing the core bearing means in a tube section and impeller rotation-measuring means, wherein, on the basis of the use of the flow sensor and the measuring range of the measuring means, a suitable tube section diameter and a suitable combination of a

calibration flow rate and an associated calibration speed are selected, whereupon the blade angle of each cross section of the blade is determined, said blade angle meeting the equation

$$[tg(H(r)) * Caldeb * C]/[r * D^2] = Calrev$$

wherein

r = distance section relative to the center of the core (m);
H(r) = blade angle of section at distance r (°);
Caldeb = calibration flow rate (m^3/h)
Calrev = calibration speed (rev/min)
D = diameter tube section (m)

wherein $0.003 < C < 0.004$ and C is preferably 6.67/1974.

18. A method according to claim 17, characterized in that a maximum and minimum flow rate to be measured during use and a maximum and minimum impeller speed desired therefor are determined, whilst for each cross section a blade angle is selected to which it applies that it lies between two limit values $H(r)_{max}$ and $H(r)_{min}$ meeting the following formulae

$$[tg(H(r)_{max}) * Maxdeb * C]/[r * D^2] < Maxrev$$

and

$$[tg(H(r)_{min}) * Mindeb * C]/[r * D^2] < Minrev$$

wherein:

r = distance section relative to the center of the core (m);
$H(r)_{max}$ = maximum blade angle section at distance r (°);
$H(r)_{min}$ = minimum blade angle section at distance r (°);
Maxdeb = maximum flow rate (m^3/h)
Mindeb = minimum flow rate (m^3/h)
Maxrev = maximum speed (rev/min)
Minrev = minimum speed (rev/min)

wherein $0.003 < C < 0.004$ and C is preferably 6.67/1974.

19. A method according to claim 17 or 18, characterized in that for each cross section of each blade, a width and blade angle are determined so that to substantially each combination of two cross sections of the blade, it applies that

$$[r_1*\cos(H_1)*B_1]/[r_2*\cos(H_2)*B_2] > 1$$

wherein:

r_1 = distance first section relative to the center of the core (m);

r_2 = distance second section relative to the center of the core (m);

wherein $r_2 > r_1$;

H_1 = blade angle first section (°);

H_2 = blade angle second section (°);

B_1 = Blade width first section (m); and

B_2 = Blade width second section (m),

and so that to all blade angles of the impeller it applies that they lie in one quadrant and that the blade angle (H) and blade width (B) have a flowing curve over the blade.

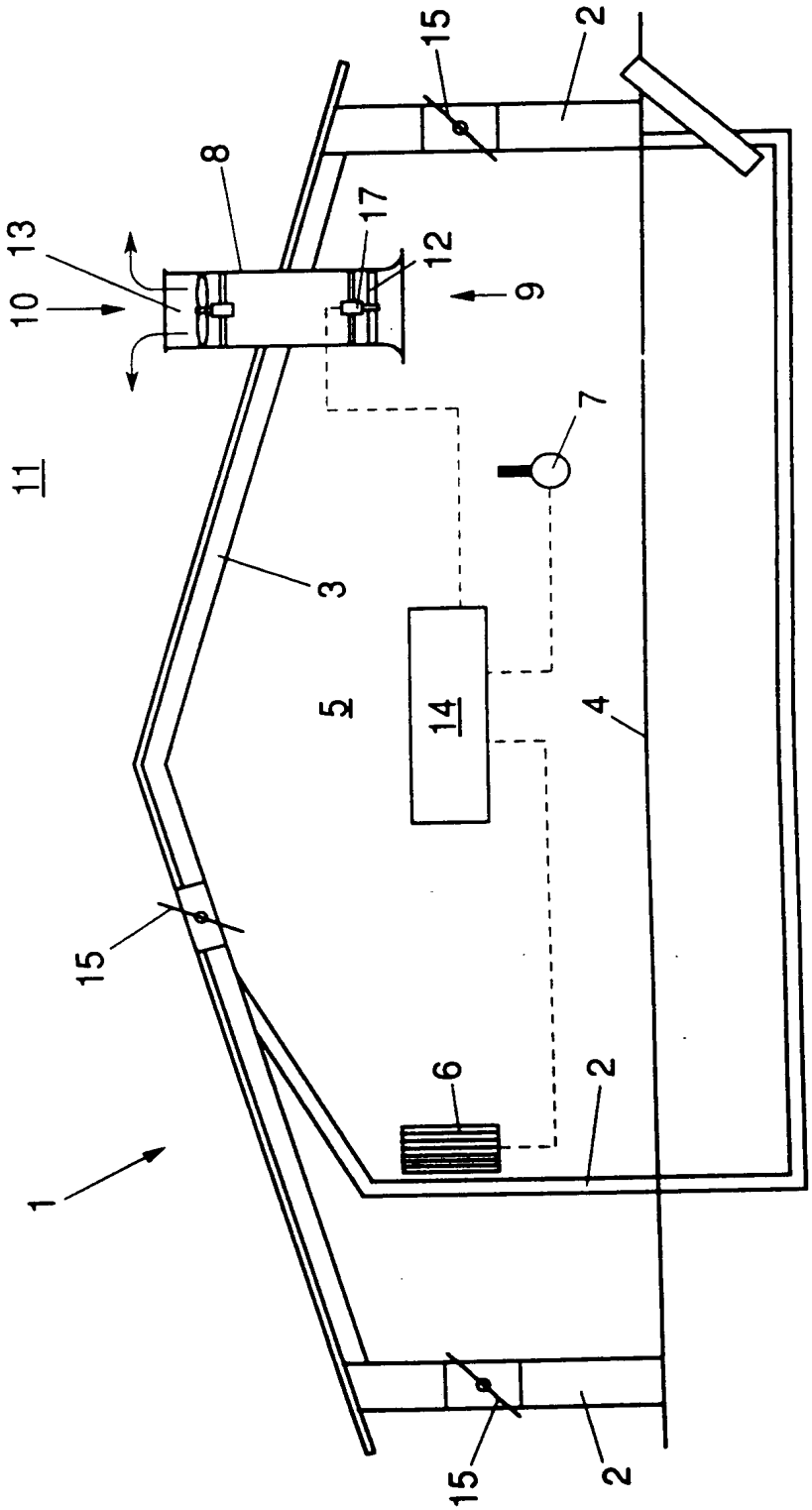

FIG. 1

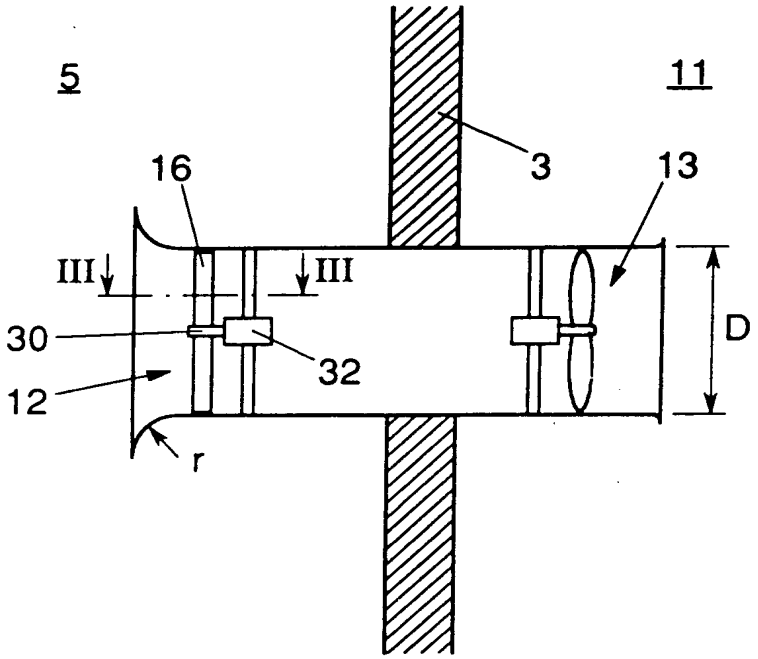

FIG. 2

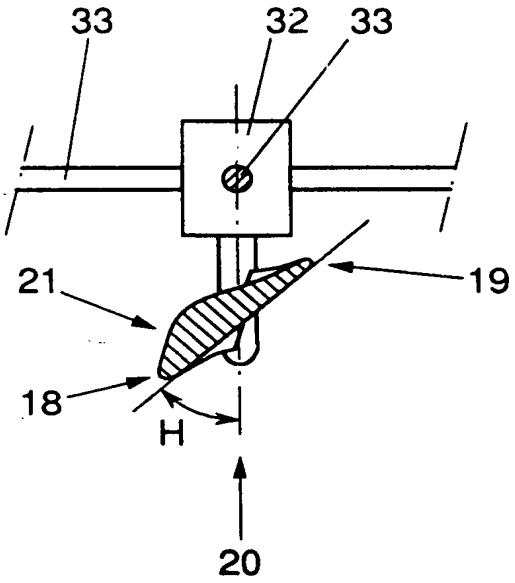

FIG. 3

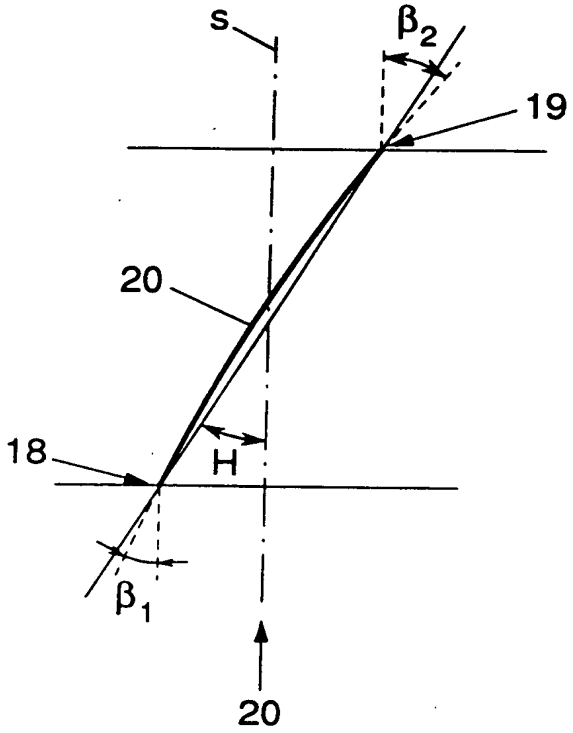

FIG. 4

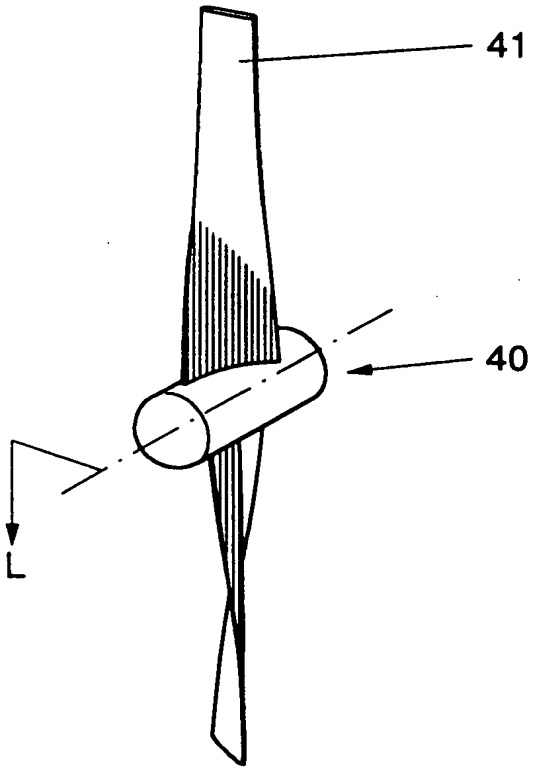

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 95/00335

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01F1/10 G01F25/00 F24F11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01F F24F A01K G01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 545 499 (INDOLEC B V) 9 June 1993 see column 12, line 32 - column 13, line 1; figure 4	1,9,14
A	EP,A,0 589 532 (KEMPENSERVICE ELEKTROTECHNIEK) 30 March 1994 see column 5, line 17 - line 53; figure 2	1,14
A	EP,A,0 100 214 (NAT RES DEV) 8 February 1984 see page 4, line 24 - page 5, line 10; figure 1	14
A	EP,A,0 016 321 (VDO SCHINDLING) 1 October 1980 see page 7, line 22 - line 30; figure 3	1

☐ Further documents are listed in the continuation of box C.

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4 January 1996	- 5. 02. 96

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Interna[illegible] l Application No
PCT/NL 95/00335

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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EP-A-0589532	30-03-94	NL-A-	9201645	18-04-94
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		AU-B-	528022	31-03-83
		AU-B-	5568380	02-10-80
		JP-C-	1286673	31-10-85
		JP-A-	56058612	21-05-81
		JP-B-	60008446	02-03-85
		US-A-	4316392	23-02-82

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
G01F 1/10, 25/00, F24F 11/00

A1

(11) International Publication Number: WO 96/10733

(43) International Publication Date: 11 April 1996 (11.04.96)

(21) International Application Number: PCT/NL95/00335

(22) International Filing Date: 3 October 1995 (03.10.95)

(30) Priority Data:
9401632 4 October 1994 (04.10.94) NL

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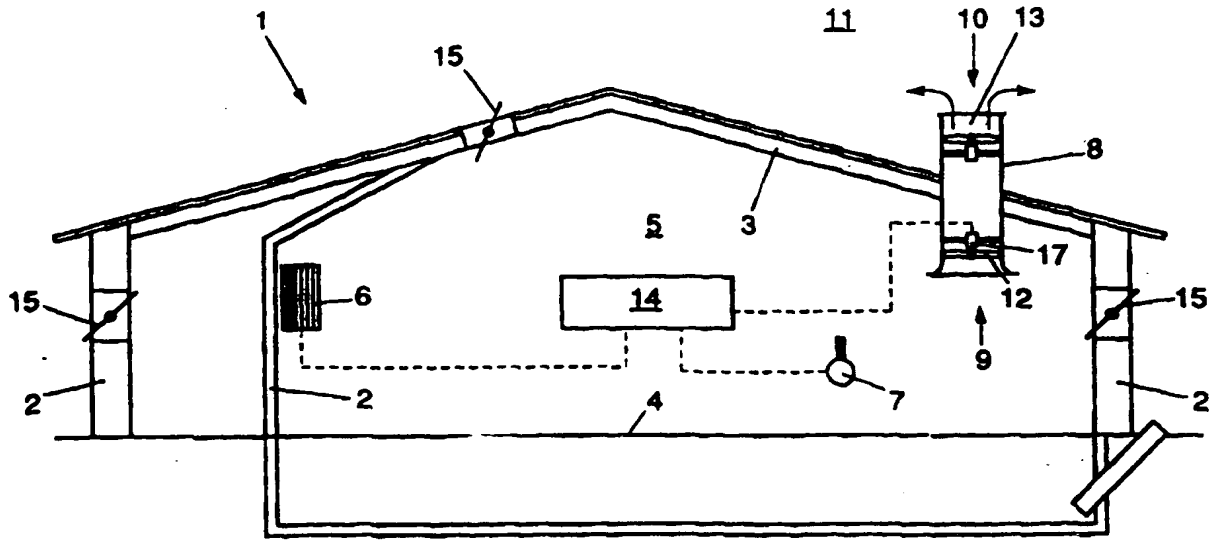
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Dutch).

(54) Title: FLOW SENSOR



(57) Abstract

A flow sensor, in particular suitable for use in air flow measuring, comprising an impeller which is suspended for free rotation in a tube section and which comprises a central core and a number of blades extending from the core, at least one blade extending from the core to adjacent the inner wall of the tube section, measuring means being included for measuring the number of revolutions of the impeller per unit of time, the flow sensor being adapted to register, when a calibration flow rate is passed through the tube, an associated calibration speed of the impeller by means of the measuring means.

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INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/NL 95/00335

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01F1/10 G01F25/00 F24F11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01F F24F A01K G01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 545 499 (INDOLEC B V) 9 June 1993 see column 12, line 32 - column 13, line 1; figure 4 ---	1,9,14
A	EP,A,0 589 532 (KEMPENSERVICE ELEKTROTECHNIEK) 30 March 1994 see column 5, line 17 - line 53; figure 2 ---	1,14
A	EP,A,0 100 214 (NAT RES DEV) 8 February 1984 see page 4, line 24 - page 5, line 10; figure 1 ---	14
A	EP,A,0 016 321 (VDO SCHINDLING) 1 October 1980 see page 7, line 22 - line 30; figure 3 -----	1

☐ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 January 1996	- 5. 02. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Heinsius, R

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Internal Application No
PCT/NL 95/00335

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EP-A-0589532	30-03-94	NL-A- 9201645	18-04-94
EP-A-0100214	08-02-84	DE-A- 3377008	14-07-88
		GB-A,B 2125191	29-02-84
EP-A-0016321	01-10-80	DE-A- 2911827	09-10-80
		AU-B- 528022	31-03-83
		AU-B- 5568380	02-10-80
		JP-C- 1286673	31-10-85
		JP-A- 56058612	21-05-81
		JP-B- 60008446	02-03-85
		US-A- 4316392	23-02-82

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 95/00335

A. CLASSIFICATION OF SUBJECT MATTER
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Minimum documentation searched (classification system followed by classification symbols)
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Heinsius, R

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Information on patent family members

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		GB-A,B	2125191	29-02-84
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		AU-B-	5568380	02-10-80
		JP-C-	1286673	31-10-85
		JP-A-	56058612	21-05-81
		JP-B-	60008446	02-03-85
		US-A-	4316392	23-02-82